Republic of South Africa

EDICT OF GOVERNMENT

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Energy efficiency in buildings

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Table of changes

Change No.	Date	Scope

Acknowledgement

The SABS Standards Division wishes to acknowledge the valuable assistance derived from the Australian Building Codes Board.

Foreword

This South African standard was approved by National Committee SABS SC 59G, *Construction standards – Energy efficiency and energy use in the built environment*, in accordance with procedures of the SABS Standards Division, in compliance with annex 3 of the WTO/TBT agreement.

This document was published in August 2011.

Reference is made in 4.5.1.1 and 4.6.1.1 to the "relevant legislation". In South Africa this means the Occupational Health and Safety Act, 1993 (Act No. 85 of 1993).

Annexes A, B, C, D and E form an integral part of this document. Annex F is for information only.

Contents

Contents (*concluded*)

Energy efficiency in buildings

1 Scope

This standard specifies the design requirements for energy efficiency in buildings and of services in buildings with natural environmental control and artificial ventilation or air conditioning systems.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies. Information on currently valid national and international standards can be obtained from the SABS Standards Division.

ASHRAE 90.1, *Energy standard for buildings except low-rise residential buildings.*

ASTM C 177, *Standard test method for steady-state heat flux measurements and thermal transmission properties by means of the guarded-hot-plate apparatus.*

ASTM C 518, *Standard test method for steady-state thermal transmission properties by means of the heat flow meter apparatus.*

ASTM C 1199, *Standard test method for measuring the steady-state thermal transmittance of fenestration systems using hot box methods.*

ASTM C 1363, *Standard test method for thermal performance of building materials and envelope assemblies by means of a hot box apparatus.*

ISO 9050, *Glass in building – Determination of light transmittance, solar direct transmittance, total solar energy transmittance, ultraviolet transmittance and related glazing factors.*

SANS 428, *Fire performance classification of thermal insulated building envelope systems.*

SANS 613, *Fenestration products – Mechanical performance criteria.*

SANS 1307, *Domestic solar water heaters.*

SANS 6211-1, *Domestic solar water heaters – Part 1: Thermal performance using an outdoor test method.*

SANS 6211-2, *Domestic solar water heaters – Part 2: Thermal performance using an indoor test method.*

SANS 10106, *The installation, maintenance, repair and replacement of domestic solar water heating systems.*

SANS 10114-1, *Interior lighting – Part 1: Artificial lighting of interiors.*

SANS 10173, *The installation, testing and balancing of air-conditioning ductwork.*

SANS 10177-5, *Fire testing of materials, components and elements used in buildings – Part 5: Non-combustibility at 750 °C of building materials.*

SANS 10252-1 *Water supply and drainage for buildings – Part 1: Water supply installations for buildings.*

SANS 10254, *The installation, maintenance, replacement and repair of fixed electric storage water heating systems.*

SANS 10400-A, *The application of the National Building Regulations – Part A: General principles and requirements.*

SANS 10400-N, *The application of the of the National Building Regulations – Part N: Glazing*.

SANS 10400-O, *The application of the National Building Regulations – Part O: Lighting and ventilation.*

NFRC 100, *Procedure for determining fenestration product U-factors*.

3 Definitions

For the purposes of this document, the definitions given in SANS 10400-A, and the following apply.

3.1
air conditioning
process of controlling indoor environment in terms of temperature, humidity, air movement and air cleanliness

3.2
air leakage
AL
performance rating indicating the amount of airflow through glazing and solid doors during laboratory tests

3.3
climatic zone
region in which the climatic conditions are similar

NOTE The zones have been adjusted to simplify use of the energy efficiency measures. A map of South Africa indicating the various climatic zones and a table specifying the zones for major cities and towns on the borders of climatic zones are given in annex A.

3.4
***C*-value**
thermal capacity ($kJ/m^2 \cdot K$) of a material, which is the ability to store heat energy, and is the arithmetical product of specific heat capacity ($kJ/kg \cdot K$), density (kg/m^3) and thickness (m)

3.5
***CR*-value**
time constant (hours) of a composite element, such as a wall, and being the arithmetical product of total *C*-value and the total *R*-value.

NOTE The higher the *CR*-value the greater the ability of the composite element to moderate and minimise the effects of external climatic conditions on the interior of a building.

3.6
direction of heat flow
most significant heat flow at a given time

NOTE Heat flow from hot to cold environments is considered to be the direction of natural heat flow. Therefore "upwards" implies heat flow from a conditioned space through the ceiling or roof, and “downwards” implies the opposite. Likewise, horizontal flows can be described as "inwards" and "outwards".

3.7
energy efficiency
minimizing energy consumption while still achieving the required output.

NOTE In the context of buildings this will be the maintenance of required indoor comfort conditions and the provision of necessary power for correct operation of all installed services. Designing for energy efficiency involves the design, selection of materials, components and systems to minimize energy consumption. Achieving energy efficiency involves design, operation, maintenance and ongoing adjustments to minimize energy consumption.

3.8
external walls
complete walling system, as measured from the outer skin exposed to the environment, to the inside of the inner skin exposed to the interior of the building, and does not include glazing

3.9
façade area
storey height multiplied by elevation length

3.10
fenestration
light transmitting section in a building wall or roof, including glazing material (which may be glass or plastic), framing (mullions, muntins and dividers), external shading devices and integral (between glasses) shading devices

3.11
glazing
windows, glazed doors or other transparent and translucent elements including their frames (such as glass bricks) located in the building envelope

3.12
mechanical ventilation
movement of air through mechanical means

3.13
natural environmental control
application of passive measures of environmental control

3.14
net floor area
sum of all areas between the vertical building components (walls or partitions), excluding garages, car parks and storerooms

3.15
orientation
direction a building envelope element faces (i.e. the direction of a vector perpendicular to and pointing away from the surface outside of the element)

3.16
reference building
hypothetical building that is used to determine the maximum allowable energy load for the proposed building

3.17
reflective insulation
material with a reflective surface such as a reflective foil laminate, reflective barrier or foil batt capable of reducing radiant heat flow

3.18
roof assemblies
roofing or ceiling system (or both), as measured from the outer skin exposed to the environment, to the inside of the inner skin exposed to the interior of the building, and does not include glazing such as roof lights and skylights

NOTE These requirements are included in 4.3.6.

3.19
***R*-value**
measurement of the thermal resistance of a material which is the effectiveness of the material to resist the flow of heat, i.e. the thermal resistance ($m^2 \cdot K/W$) of a component calculated by dividing its thickness by its thermal conductivity

3.20
skillion roof
monopitch roof assembly where the ceiling follows the slope of the rafters

3.21
solar heat gain coefficient
SHGC
measure of the amount of solar radiation (heat) passing through the glazing

NOTE *SHGC* is expressed as a number between 0 and 1,0; the lower the *SHGC*, the lower the heat gain.

3.22
thermal capacity
ability of a material to store heat energy

NOTE Thermal capacity is measured as a *C*-value; the higher the *C*-value the greater the heat storing capability.

3.23
thermal resistance
resistance to heat transfer across a material

NOTE Thermal resistance is measured as an *R*-value; the higher the *R*-value the better the ability of the material to resist heat flow.

3.24
total *C*-value
sum of the *C*-values of the individual component layers in a composite element including the air space

3.25
total *R*-value
sum of the *R*-values of the individual component layers in a composite element including the air space and associated surface resistances, in accordance with an internationally recognized test or calculation method

3.26
total *U*-value
thermal transmittance ($W/m^2\cdot K$) of the composite element including the air space and associated surface transmittance

NOTE 1 The *U*-value addresses the ability of a material to conduct heat, while the *R*-value measures the ability to resist heat flow; the higher the *U*-value number, the greater the amount of heat that can pass through that material. A lower value would mean a better insulator.

NOTE 2 The *U*-value is measured under NFRC 100 test conditions but varies with environmental conditions to which the insulator is exposed (such as temperature, wind velocity and indoor air movement).

3.27
visible transmittance
VT
amount of visible light that comes through glazing

NOTE Visible transmittance is expressed as an number between 0 and 1,0; the higher the number, the more light is transmitted and the better the VT.

4 Requirements

4.1 Site orientation

Site layouts shall enable buildings to be designed for optimal orientation given in figures B.1 to B.6 or approximately true north.

4.2 Building orientation

Buildings should be orientated in accordance with figures B.1 to B.6, or approximately true north. If buildings cannot be thus orientated, they shall be orientated to achieve the lowest net energy use. Orientation sectors are shown in figure 1.

Living spaces should be arranged so that the rooms where people spend most of their hours are located on the northern side of the unit. Uninhabited rooms such as bathrooms and storerooms can be used to screen unwanted western sun or to prevent heat loss on the south facing façades. Living rooms should ideally be placed on the northern side.

The longer axis of the dwelling should be orientated so that it runs as near east/west as possible.

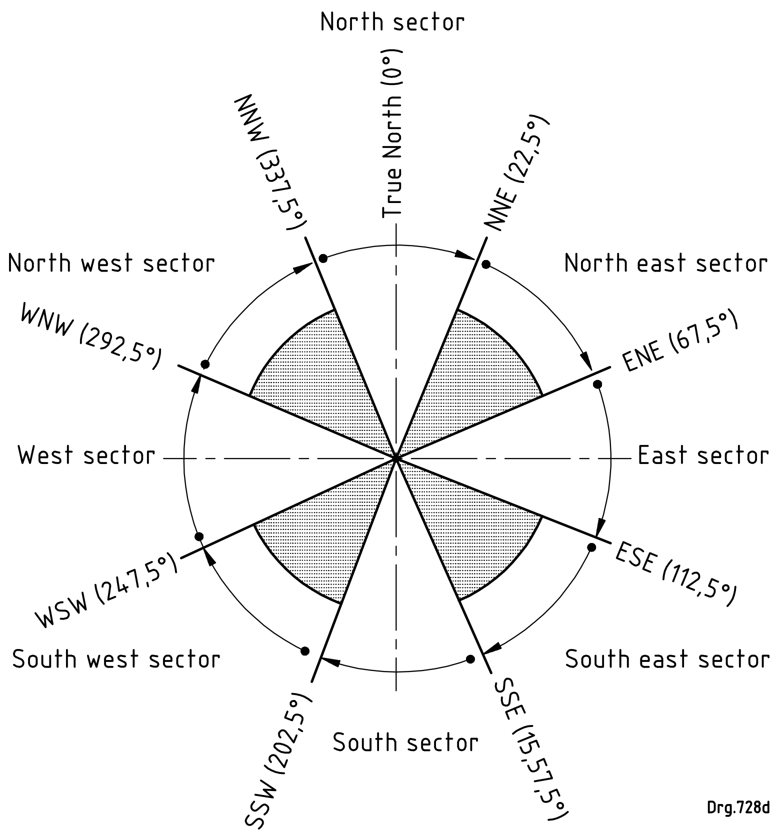


Figure 1 — Orientation sectors

4.3 Building design

4.3.1 General

Energy efficiency performance requirements of this standard shall be satisfied by the following:

a) the application of the provisions of 4.1 to 4.6;

b) by rational design that demonstrates equivalent to, or better than, the performance of a reference building using the provisions given in 4.1 to 4.6; or

c) compliance with tables 1 and 2.

Table 1 — Maximum energy demand per building classification for each climatic zone

1	2	3	4	5	6	7	8
Classification of occupancy of building	**Description of building**	**Maximum energy demand**[a] VA/m^2					
		Climatic zone[b]					
		1	**2**	**3**	**4**	**5**	**6**
A1	Entertainment and public assembly	85	80	90	80	80	85
A2	Theatrical and indoor sport	85	80	90	80	80	85
A3	Places of instruction	80	75	85	75	75	80
A4	Worship	80	75	85	75	75	80
F1	Large shop	90	85	95	85	85	90
G1	Offices	80	75	85	75	75	80
H1	Hotel	90	85	95	85	85	90

[a] The maximum demand shall be based on the sum of 12 consecutive monthly maximum demand values per area divided by 12/m^2 which refers to the net floor area.

[b] The climatic zones are given in annex A.

Table 2 — Maximum annual consumption per building classification for each climatic zone

1	2	3	4	5	6	7	8
Classification of occupancy of building	**Description of building**	**Maximum energy consumption**[ab] kWh/m^2					
		Climatic zone[c]					
		1	**2**	**3**	**4**	**5**	**6**
A1	Entertainment and public assembly	420	400	440	390	400	420
A2	Theatrical and indoor sport	420	400	440	390	400	420
A3	Places of instruction	420	400	440	390	400	420
A4	Worship	120	115	125	110	115	120
F1	Large shop	240	245	260	240	260	255
G1	Offices	200	190	210	185	190	200
H1	Hotel	650	600	585	600	620	630

[a] The annual consumption per square metre shall be based on the sum of the monthly consumption of 12 consecutive months.

[b] Non-electrical consumption, such as fossil fuels, shall be accounted for on a non-renewable primary energy thermal equivalence basis by converting mega joules to kilowatt hours.

[c] The climatic zones are given in annex A.

4.3.2 Floors

4.3.2.1 With the exception of zone 5 (see annex A), buildings with a floor area of less than 500 m^2, with a concrete slab-on-ground, shall have insulation installed around the vertical edge of its perimeter which shall

a) have an *R*-value of not less than 1,0,

b) resist water absorption in order to retain its thermal insulation properties, and

c) be continuous from the adjacent finished ground level

1) to a depth of not less than 300 mm, or

2) for the full depth of the vertical edge of the concrete slab-on-ground.

4.3.2.2 Where an underfloor (in-screed, under floor heating, underlaminate heating, undercarpet heating, undertile heating, cut-in under floor heating or waterbased under floor heating) heating system is installed, the heater shall be insulated underneath the slab with insulation that has a minimum *R*-value of not less then 1,0.

4.3.2.3 With the exception of climatic zone 5, a suspended floor that is part of a building's envelope shall have insulation that shall retain its thermal properties under moist conditions and be installed

a) for climatic zones 1 and 2, with a partially or completely unenclosed exterior perimeter, and shall achieve a total *R*-value of 1,5,

b) for climatic zones 3, 4 and 6, with a partially or completely unenclosed exterior perimeter, and shall achieve a total *R*-value of 1,0, and

c) with an in-slab in floor heating system, and shall be insulated around the vertical edge of its perimeter and underneath the slab with insulation having a minimum *R*-value of not less than 1,0.

NOTE Care should be taken to ensure that any required termite management system is not compromised by slab edge insulation. In particular the inspection distance should not be reduced or concealed behind the insulation.

4.3.3 External walls

4.3.3.1 Masonry walls such as, but not limited to, cavity, grouted cavity, diaphragm, collar-jointed and single leaf masonry, shall achieve the minimum *CR*-value given in table 3 for the different types of occupancies in the different climatic zones (see climatic zones in annex A).

NOTE For the *CR*-values of walls, contact the relevant manufacturer(s). Table 4 provides typical values for double brick masonry walls, with or without additional insulation.

Table 3 – Minimum *CR*-value, in hours, for external walling

1	2	3	4	5	6	7
Occupancy group	**Climatic zone**					
	1	**2**	**3**	**4**	**5**	**6**
	Number of hours					
Residential: E1 to E4, H1 to H5	100	80	80	100	60	90
Office and institutional: A1 to A4, C1 to C2, B1 to B3, G1	80	80	100	100	80	80
Retail: F1 to F3	80	80	120	80	60	100
Unclassified: A5, D1 to D4, J1 to J4	NR	NR	NR	NR	NR	NR
NR = No requirement						
NOTE Masonry walls refer to the external walls of the habitable portions of the building fabric only; therefore, there are no requirements for balustrade, foundation, free-standing, parapet and retaining walls.						

Table 4 – Typical *CR*-values

1	2
Double brick wall type	***CR*-value** h
No cavity	40
With 50 mm air cavity	60
With *R* = 0,5 cavity insulation	90
With *R* = 1 cavity insulation	130

NOTE 1 *R* = 0,5 and *R* = 1,0 refers to the thermal resistance of the insulation only, expressed in m^2K/W. Thermal resistance that is added to external walling with high thermal capacity, should be placed in between layers, for example in the cavity of a masonry wall. Thermal resistance should not be added to the internal face of a wall with high thermal capacity.

NOTE 2 Wall systems that have low thermal capacity or resistance (or both) will not meet the requirements given in 4.3.3.1.

NOTE 3 Designers should consider that interstitial condensation occurs in walling systems which are not able to prevent or accommodate moisture migration. The selection of vapour barriers and appropriate construction materials, including insulation, is important for the thermal efficiency of walling in climate zones where damp and high relative humidity is experienced.

NOTE 4 Internal walls in buildings with external walling should ideally have *CR*-values of at least 20 h. However, this is not a requirement for compliance.

NOTE 5 The climatic zones are given in annex A.

4.3.3.2 External non-masonry walls shall

a) achieve the *CR*-values given in table 3 by the addition of capacity, or resistance (or both),

b) have the following minimum *R*-values (except A5, D1 to D4, J1 to J4 which have no minimum *R*-value requirements):

1) for climatic zones 1 and 6, a total *R*-value of 2,2; and

2) for climatic zones 2, 3, 4 and 5, a total *R*-value of 1,9; or

c) have *R*-values that comply with the requirements of ASTM C 177, ASTM C 518 and ASTM C 1363.

NOTE Internal walls in buildings with this type of external walling may be masonry or non-masonry.

4.3.3.3 Attached buildings such as garages, glasshouses, solariums or pool enclosures to the main building shall

a) have an external fabric that achieves the required level of thermal performance for that building,

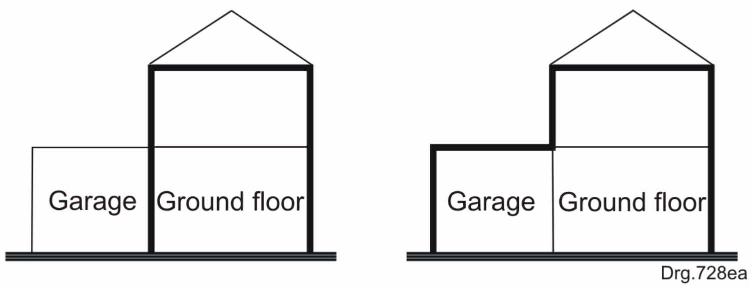
b) be separated from the main building with construction having the required level of thermal performance for the building (see figure 2), or

c) not compromise the thermal performance of the main building.

4.3.3.4 In addition, an attached building can only be exempted from the regulations if it does not contain habitable spaces and is not provided with a heating/cooling installation, or if any heating/cooling installation is entirely fed from renewable energy sources.

NOTE 1 In figure 2 option A, the thermal performance required for the main building may be achieved by the outside walls and floor of the garage.

NOTE 2 In figure 2 option B, the thermal performance required for the main building may be achieved by the walls and floor of the main building as if the garage were an under-floor space with an enclosed perimeter.



Option A — Elevation **Option B — Elevation**

Figure 2 — Separation of attachments

4.3.4 Fenestration

4.3.4.1 Fenestration for buildings with natural environmental control

4.3.4.1.1 The air leakage (AL) of external vertical glazing in each storey of a sole-occupancy unit, public space or other occupied space shall be assessed separately in accordance with 4.4.3.1.2 and 4.4.3.1.3.

4.3.4.1.2 The aggregate conductance and solar heat gain (*SHGC*) of the glazing in each storey shall not exceed the values obtained by multiplying the net floor area measured within the enclosing walls with the constants, C_U for conductance and C_{SHGC} for solar heat gain given in table 5.

Table 5 — Constants for conductance and *SHGC*

1	2	3	4	5	6	7
Constants	**Climatic zone**					
	1	**2**	**3**	**4**	**5**	**6**
Conductance C_U	1,2	1,4	1,4	1,4	1,4	1,2
SHGC C_{SHGC}	0,15	0,12	0,10	0,13	0,11	0,13

4.3.4.1.3 The aggregate conductance and *SHGC* of the glazing in each storey shall be calculated by adding the conductance and *SHGC* of each glazing element to the following equations:

a) For conductance

$$(A_1 \times U_1) + (A_2 \times U_2) + (A_3 \times U_3) + \ldots$$

where

$A_{1,2,3}$ is the area of each glazing element (where 1, 2, 3, etc., refer to the specific glazing element);

$U_{1,2,3}$ is the *U*-value of each glazing element (where 1, 2, 3, etc., refer to the specific glazing element) (see table 6).

b) For *SHGC*

$$(A_1 \times S_1 \times E_1) + (A_2 \times S_2 \times E_2) + (A_3 \times S_3 \times E_3) + \ldots$$

where

$A_{1,2,3}$ is the area of each glazing element (where 1, 2, 3, etc., refer to the specific glazing element);

$S_{1,2,3}$ is the *SHGC* of the transparent or translucent element in each glazing element (where 1, 2, 3, etc., refer to the specific glazing area) (see table 6);

$E_{1,2,3}$ is the solar exposure factor for each glazing element obtained from the tables in annex C (where 1, 2, 3, etc., refer to the specific glazing element).

4.3.4.1.4 The *U*-values and *SHGC* values, in accordance with table 6 (worst-case glazing element performance), shall be used unless these values are supplied by the glazing manufacturers as verified in accordance with ASTM C 1199 and ISO 9050 for *U*-values, and given in NFRC 100 for *SHGC* values.

4.3.4.1.5 A building wall, including the glazing it contains, shall be considered to face north if it faces any direction in the north orientation sector given in figure 1. The orientation of other walls, including the glazing they contain, shall be determined in a similar way.

Table 6 — Worst-case whole glazing element performance values

1	2	3	4	5
Glass description	**Performance values**			
	Aluminium/Steel framing		**Timber/PVCu/Aluminium thermal break framing**	
	Total *U*-value W/m²·K	***SHGC***	**Total *U*-value** W/m²·K	***SHGC***
Single – Clear	7,9	0,81	5,6	0,77
Single – Tinted	7,9	0,69	5,6	0,65
Single – Low *E*[a]	5,73	0,66	4,06	0,63
Clear double[b] (3/6/3)	4,23	0,72	3,0	0,68
Tinted double[b]	4,23	0,59	3,00	0,56
Clear double[b] low *E*[a]	3,40	0,66	2,41	0,62
Tinted double[b] low *E*[b]	3,40	0,54	2,41	0,51

NOTE 1 Glazing elements require total *U*-values and *SHGC*s and are assessed for the combined effect of glass and frames. The measurements of these total *U*-values and *SHGC*s are specified in the guidelines of the National Fenestration Rating Council (NFRC).

NOTE 2 *U*-value and *SHGC*s, based on the NFRC assessment methods are shown for some simple types of glazing elements in this table. (Smaller numbers indicate better glazing element performance.) This table gives worst case assessments which can be improved by obtaining generic or custom product assessments from suppliers, manufacturers, industry associations (including their online resources) and from competent assessors.

[a] Low *E* assumes emissivity of 0,2, or better.

[b] Low *E* coating to surface 3 of the double glazed unit.

4.3.4.2 Fenestration for buildings with centrally controlled artificial ventilation or air conditioning

4.3.4.2.1 The air leakage of external vertical glazing in each storey of a sole-occupancy unit, public space, or other occupied space, shall be assessed separately in accordance with 4.4.3.2.2 and 4.4.3.2.3.

4.3.4.2.2 The aggregate air-conditioning energy value attributable to the value shall not exceed the allowance obtained by multiplying the façade area of the orientation by the energy index given in table 7.

Table 7 — Energy index

1	2	3	4	5	6
Climatic zone					
1	**2**	**3**	**4**	**5**	**6**
0,220	0,257	0,221	0,220	0,180	0,227

4.3.4.2.3 The aggregate air-conditioning energy value shall be calculated by adding the air-conditioning energy value through each value element in accordance with the following equation:

$$A_1 [S_1 (C_A \times S_{H1} + C_B \times S_{C1}) + C_C \times U_1] + A_2 [S_2 (C_A \times S_{H2} + C_B \times S_{C2}) + C_C \times U_2] + \ldots$$

where

$A_{1, 2, 3}$ is the area of each glazing element (where 1, 2, 3, etc., refer to the specific glazing element);

$S_{1, 2, 3}$ is the *SHGC* of each glazing element given in table 5 (where 1, 2, 3, etc., refer to the specific glazing element);

$C_{A, B, C}$ are the energy constants given in table D.1 (see annex D);

$S_{H1, H2, H2}$ is the heating shading multiplier element for each value element given in table D.2 (where H_1, H_2, H_3, etc., indicate the specific heating shading multiplier element);

$S_{C1, C2, C3}$ is the cooling shading multiplier element for each glazing element given in table D.3 (where C_1, C_2, C_3, etc., indicate the specific cooling shading multiplier element);

$U_{1, 2, 3}$ is the total *U*-value of each glazing element given in table 6 (where 1, 2, 3 etc., indicate the specific glazing element).

4.3.4.2.4 For the purposes of 4.3.4.2.3, where the air-conditioning energy value of a value element is calculated to be negative, the energy value shall be taken to be zero.

4.3.5 Shading

4.3.5.1 Where shading is used, the building shall

a) have a permanent feature such as a veranda, balcony, fixed canopy, eaves or shading hood, which

1) extends horizontally on both sides of the glazing for the same projection distance, *P* in figure 3, or

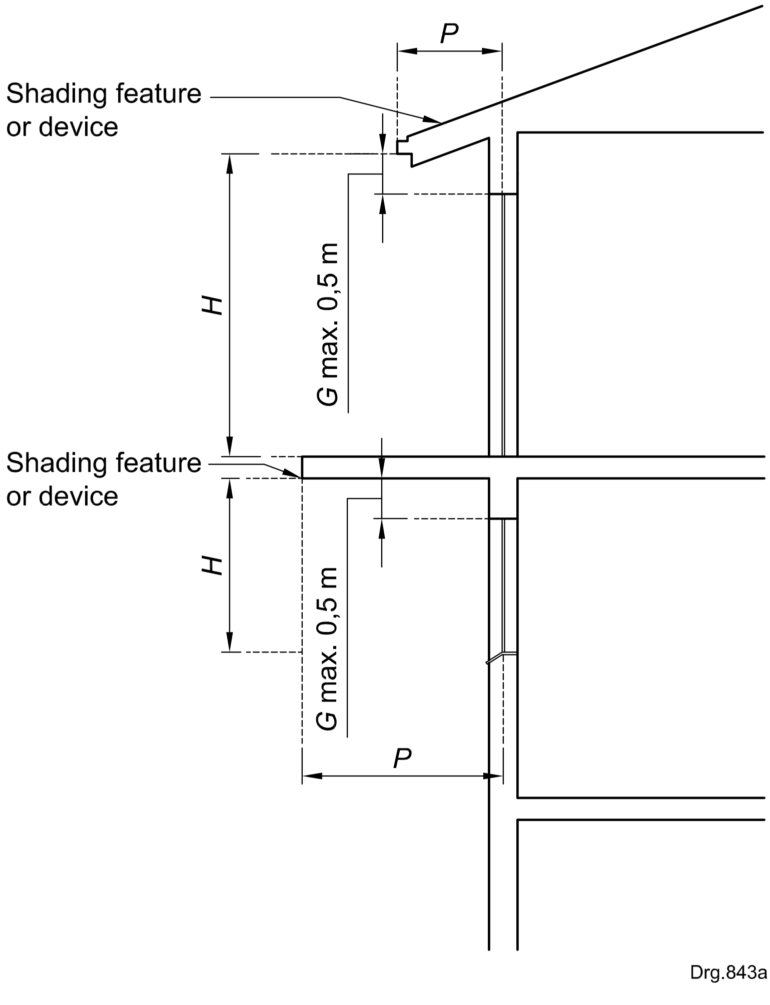
2) provides the equivalent shading with a reveal or other shading element (see figure 4),

b) have an external shading device, such as a shutter, blind, vertical or horizontal building screen with blades, battens or slats, which

1) is capable of restricting at least 80 % of summer solar radiation, and

2) if adjustable, is readily operated either manually, mechanically or electronically by the building occupants.

4.3.5.2 For glazing where *G* exceeds 0,5 m, the value of *P* (see figure 3) shall be halved. (See annex E for an example of this calculation.)



Key

P horizontal distance, expressed in metres, from the glass face to the shadow casting edge of any shading projection

H vertical distance from the base of the glazing element to the same shadow casting edge used to measure *P*

G vertical distance from the head of the glazing element to the shadow casting edge of any shading projection

NOTE An adjustable shading device that is capable of completely covering the glazing may be considered to achieve a *P/H* value of 2.

Figure 3 — Method of measuring *P* and *H*

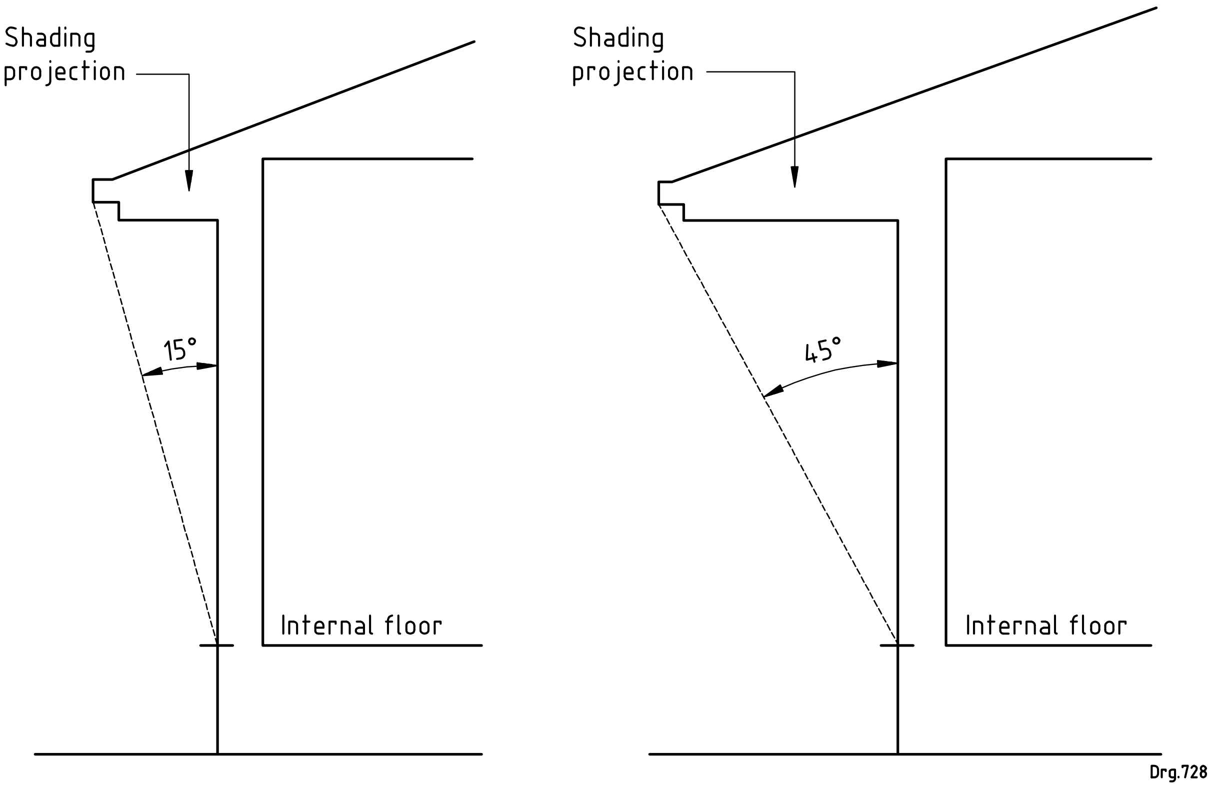


Figure 4 — Shading illustration

4.3.6 Roof assemblies

4.3.6.1 General

4.3.6.1.1 A roof assembly shall achieve the minimum total *R*-value specified in table 8 for the direction of heat flow.

Table 8 — Minimum total *R*-values of roof assemblies

1	2	3	4	5	6
Climatic zones					
1	**2**	**3**	**4**	**5**	**6**
Minimum required total *R*-value $m^2 \cdot K/W$					
3,7	3,2	2,7	3,7	2,7	3,5
Direction of heat flow					
Up	Up	Down and up	Up	Down	Up

4.3.6.1.2 A roof assembly that has metal sheet roofing fixed to metal purlins, metal rafters or metal battens shall have a thermal break consisting of a material with an *R*-value of not less than 0,2 installed between the metal sheet roofing and its supporting member.

See annex F for typical roof assembly construction and *R*-values of materials.

4.3.6.2 Thermal insulation

4.3.6.2.1 Insulation shall comply with minimum required *R*-values and be installed so that it

a) abuts or overlaps adjoining insulation, or is sealed,

b) forms a continuous barrier with ceilings, walls, bulkheads or floors that contribute to the thermal barrier, and

c) does not affect the safe or effective operation of any services, installation, equipment or fittings.

4.3.6.2.2 Thermal insulation material shall be either

a) non-combustible when tested in accordance with SANS 10177-5, and may be installed in all occupancy classes; or

b) classified as combustible in accordance with SANS 10177-5, and shall be tested and classified in accordance with SANS 428 for its use and application.

4.3.6.2.3 Reflective insulation shall be installed and supported:

a) with the necessary airspace in accordance with table 9 in order to achieve the required *R*-value between a reflective side of the reflective insulation and a building lining or cladding,

b) with the reflective insulation tightly fitted and taped against any penetration, door or window opening, and

c) with each adjoining sheet of roll membrane being

   1) overlapped by not less than 100 mm, or

   2) taped together.

The *R*-value of reflective insulation is affected by the airspace between a reflective side of the reflective insulation and the building lining or cladding. Dust build-up reduces *R*-values. Table 9 gives typical *R*-values for reflective insulation in specific circumstances.

NOTE See table 10 regarding typical *R*-values for roof/ceiling construction and the resulting typical intervention insulation thicknesses.

Table 9 — *R*-values considered to be achieved by reflective foil laminates

1	2	3	4	5	6	7	8
Emissivity of added reflective insulation	**Direction of heat flow**	***R*-value added by reflective foil insulation**					
		Pitched roof (≥10°) with horizontal ceiling		**Flat skillion or pitched roof (≤10°) with horizontal ceiling**	**Pitched roof with cathedral ceilings °C**		
		Natural ventilated roof space	**Non-ventilated roof space**		**22°**	**30°**	**45°**
0,2 outer 0,05 inner	Downwards	1,21	1,12	1,28	0,96	0,86	0,66
0,2 outer 0,05 inner	Upwards	0,59	0,75	0,68	0,72	0,74	0,77
0,9 outer 0,05 inner	Downwards	1,01	0,92	1,06	0,74	0,64	0,44
0,9 outer 0,05 inner	Upwards	0,40	0,55	0,49	0,51	0,52	0,53

NOTE 1 Reflective foil insulation values include a 15 mm air gap (see BCA 2007). Reflective insulation should work in conjunction with an air gap to be effective.

NOTE 2 The reflective surface with the lowest emissivity should preferably be facing downwards.

4.3.6.2.4 Bulk insulation shall be installed so that

a) it maintains its position and thickness, other than where it crosses roof battens, water pipes or electrical cabling, and

b) in ceilings, it overlaps the wall member by not less than 50 mm, or is tightly fitted against a wall where there is no insulation in the wall.

Table 10 gives typical data and deemed-to-satisfy thicknesses of generic insulation products.

Table 10 — Typical data and deemed-to-satisfy thicknesses of generic insulation products

1			2	3	4	5	6	7
Description			**Climatic zones**					
			1	**2**	**3**	**4**	**5**	**6**
Minimum required total *R*-value (m^2·K/W)			3,7	3,2	2,7	3,7	2,7	3,5
Direction of heat flow			Up	Up	Down and up	Up	Down	Up
Estimated total *R*-Value (m^2·K/W) of roof and ceiling materials(Roof covering and plasterboard only)			0,35 to 0,40				0,41 to 0,53	0,35 to 0,40
Estimated minimum added *R*-Value of insulation (m^2·K/W)			2,30 to 3,35				2,15 to 2,29	3,10 to 3,15
Generic insulation products	**Density** kg/m^3	**Thermal conductivity** W/m·K	**Recommended deemed-to-satisfy minimum thickness of insulation product** mm					
Cellulose fibre loose-fill	27,5	0,040	135	115	100	135	100	130
Flexible fibre glass blanket	10 to 18	0,040	135	115	100	135	100	130
Flexible BOQ polyester fibre blanket	24	0,038	130	110	90	130	90	125
Flexible polyester blanket	11,5	0,046	160	140	120	160	110	150
Flexible mineral/rockwool	60 to 120	0,033	115	100	80	115	80	100
Flexible ceramic fibre	84	0,033	115	100	80	115	80	100
Rigid expanded polystyrene (EPS)SD	15	0,035[a]	120	100	90	120	80	115
Rigid extruded polystyrene (XPS)	32	0,028[a]	100	80	70	100	65	90
Rigid fibre glass board	47,5	0,033	115	100	80	115	80	100
Rigid BOQ polyester fibre board	61	0,034	115	100	80	115	80	110
Rigid polyurethane board	32	0,025[a]	85	70	60	85	60	80
NOTE The deemed-to-satisfy recommended levels of insulation can be achieved by the use of reflective foils, bulk insulation or rigid board insulation or in combination with one another. Maximum efficiency may be achieved at reduced thicknesses taking the aforementioned into account.								
[a] Thermal efficiencies are dependant on material thickness, density, age, operating temperature and moisture.								

EXAMPLE

Climatic zone: First determine the climatic zone in which the building is to be located before applying the deemed-to-satisfy provisions. The climatic zone map of South Africa (see annex A) shows diagrammatically the extent of each zone and the table detailing the applicable climatic zone for common locations. In this case, the applicable climatic zone for Cape Town is 4.

Insulation: Roofs in climatic zone 4 are required to achieve a minimum total *R*-value of 3,7 in the upwards direction (see table 8). A pitched tiled roof with a flat ceiling in climatic zone 4 achieves a total *R*-value of 0,35. This means that additional insulation that achieves a minimum *R*-value of 3,35 (3,7 to 0,35) in the upward direction is required to be installed in the roof. This can be achieved by installing bulk insulation or a combination of bulk and reflective insulation.

Compression of bulk insulation: The *R*-value of bulk insulation is reduced if it is compressed. The allocated space for bulk insulation therefore allows the insulation to be installed so that it maintains its correct thickness. This is particularly relevant to wall and cathedral ceiling framing whose members can only accommodate a limited thickness of insulation. In some instances, larger framing members or thinner insulation material, such as polystyrene boards, may be necessary to ensure that the insulation achieves its required *R*-value.

4.3.7 Roof lights

Roof lights serving a habitable room, public area or an interconnecting space such as a corridor, hallway or stairway shall

a) if the total area of roof lights is more than 1,5 % but not more than 10 % of the floor area or space they serve, comply with table 11; and

b) if the total area of roof lights is more than 10 % of the floor area of the room or space they serve, only be used where the transparent and translucent elements of the roof lights, including any imperforate ceiling diffuser, achieves an *SHGC* of not more than 0,25 and a total *U*-value of not more than 2,0.

NOTE The thermal performance of an imperforate ceiling diffuser may be included in the total *U*-value of a roof light.

Table 11 — Roof lights — Thermal performance of transparent and translucent elements

<table>
<tr><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td></tr>
<tr><td rowspan="3">Roof light shaft index[a]</td><td colspan="6">Total area of roof lights serving the room or space as a percentage of the floor area of the room or space
W/m²K</td></tr>
<tr><td colspan="2">1,5 % to 3 %</td><td colspan="2">3 % to 5 %</td><td colspan="2">5 % to 10 %</td></tr>
<tr><td>SHGC</td><td>Total U-value
W/m²K</td><td>SHGC</td><td>Total U-value
W/m²K</td><td>SHGC</td><td>Total U-value
W/m²K</td></tr>
<tr><td>< 0,5</td><td>≤ 0,75</td><td rowspan="4">≤ 5,0</td><td>≤ 0,50</td><td rowspan="4">≤ 5,0</td><td>≤ 0,25</td><td rowspan="4">≤ 2,5</td></tr>
<tr><td>0,5 <1,0</td><td>–</td><td>≤ 0,70</td><td>≤ 0,35</td></tr>
<tr><td>1,0 < 2,5</td><td>–</td><td>–</td><td>≤ 0,45</td></tr>
<tr><td>> 2,5</td><td>–</td><td>–</td><td>–</td></tr>
<tr><td colspan="7">NOTE 1 The total area of roof lights is the combined area for all roof lights serving the room or space.
NOTE 2 The area of a roof light is the area of the roof opening that allows light to enter the building.</td></tr>
<tr><td colspan="7">[a] The roof light shaft index is determined by measuring the distance from the centre of the shaft at the roof to the centre of the shaft at the ceiling level and dividing it by the average internal dimension of the shaft opening at the ceiling level (or the diameter for a circular shaft) in the same unit of measurement.</td></tr>
</table>

4.4 Building sealing

4.4.1 Building envelope

Roofs, external walls, and floors that form the building envelope and any opening such as windows and doors in the external fabric shall be constructed to minimize air leakage. The building sealing can be done by methods such as caulking, or adding skirting, architraves or cornices.

4.4.2 Air infiltration and leakage

In climatic zones 1, 2, 4 and 6 (see annex A) the ceiling voids and attics shall be designed so as to minimize air infiltration. Accordingly, wall plate and roof junctions shall be sealed. All tile roofs in these climatic zones shall have a tile underlay or radiant barrier and the joints shall be sealed. The joints in sheeted roofs shall be sealed.

4.4.3 Permissible air leakage (AL)

4.4.3.1 Glazing and rooflights

4.4.3.1.1 Maximum permissible AL for openable glazing shall be 2,0 L/s·m^2 with a pressure difference of 75 Pa, when tested in accordance with SANS 613.

4.4.3.1.2 Maximum permissible AL for non-openable glazing shall be 0,31 L/s·m^2 with a pressure difference of 75 Pa, when tested in accordance with SANS 613.

4.4.3.1.3 For glazed double action swing doors and revolving doors, the maximum permissible AL shall be 5,0 L/s·m^2 with a pressure difference of 75 Pa, when tested in accordance with SANS 613.

4.4.3.2 Chimneys and flues

The chimney or flue of an open solid-fuel burning appliance shall be provided with a damper or flap that can be closed to seal the chimney or flue.

NOTE A solid-fuel burning device is a heater that burns material such as timber or coal. This does not apply to gas and liquid fuel burning devices.

4.4.3.3 Roof lights and skylights

4.4.3.3.1 Roof lights and skylights shall be sealed, or be capable of being sealed to minimize AL.

4.4.3.3.2 Roof lights and skylights shall be constructed with a compressible seal if they are openable.

4.4.3.4 External doors

4.4.3.4.1 A seal to restrict AL shall be fitted to each edge of an external door and other such opening that

a) serves a conditioned space, or

b) serves a habitable room in climatic zones 1, 2, 4 and 6.

4.4.3.4.2 The seal may be a foam or rubber compressible strip or a fibrous seal.

4.4.3.4.3 External swing doors shall be fitted with a draught protection device to the bottom edge on each leaf.

4.4.3.5 Exhaust fans

An exhaust fan shall be fitted with a sealing device such as a self-closing damper or filter when serving

a) a conditioned space, or

b) a habitable room in climatic zones 1, 2, 4 and 6.

4.4.3.6 Roofs, walls and floors

Roofs, external walls, external floors and any opening such as glazing or door in the external fabric, shall be constructed to minimize air leakage in accordance with 4.4.1 when forming part of the external fabric of

a) a conditioned space, or

b) a habitable room in climatic zones 1, 2, 4 and 6.

4.5 Services

4.5.1 Lighting and power

4.5.1.1 Depending upon occupancy and activity, the minimum lighting levels shall be determined in accordance with the requirements of SANS 10114-1 and SANS 10400-O. Compliance with the relevant national legislation (see foreword) is necessary for safety.

4.5.1.2 Designers are encouraged to use daylighting in their designs to reduce the energy used.

4.5.1.3 The energy demand (power) and energy consumption for the building shall be determined in accordance with the requirements given in table 12.

4.5.2 Hot water services

4.5.2.1 A minimum of 50 % by volume of the annual average hot water heating requirement shall be provided by means other than electrical resistance heating, including, but not limited to, solar heating, heat pumps, heat recovery from other systems or processes.

4.5.2.2 The solar water heating systems shall comply with SANS 1307 and SANS 10106, based on the thermal performance determined in accordance with the provisions of SANS 6211-1 and SANS 6211-2. The installation thereof shall comply with SANS 10254.

4.5.2.3 Hot water usage should be minimized and the system maintained in accordance with the requirements given in SANS 10252-1.

4.5.2.4 All exposed pipes to and from the hot water cylinders and central heating systems shall be insulated with pipe insulation material with an *R*-value in accordance with table 13.

4.5.2.5 Insulation shall

a) be protected against the effects of weather and sunlight,

b) be able to withstand the temperatures within the piping, and

c) achieve the minimum total *R*-value given in table 13.

Table 12 — Maximum energy demand and energy consumption for lighting for the class of occupancy or building

1	2	3	4	5
Class of occupancy or building	**Occupancy**	**Population**	**Energy demand** W/m²	**Energy consumption** kWh/m^2
A1	Entertainment and public assembly	Number of seats or 1 person/m²	10	25
A2	Theatrical and indoor sport	Number of seats or 1 person/m²	10	25
A3	Places of instruction	1 person/5 m²	10	25
A4	Worship	Number of seats or 1 person/m²	10	10
A5	Outdoor sport is viewed	Number of seats or 1 person/m²	10	15
B1	High-risk commercial	1 person/15 m²	24	60
B2	Moderate-risk commercial	1 person/15 m²	20	50
B3	Low-risk commercial	1 person/15 m²	15	37,5
C1	Exhibition halls	1 person/10 m²	15	22,5
C2	Museums	1 person/20 m²	5	12,5
D1	High-risk industrial	1 person/15 m²	20	50
D2	Moderate-risk industrial	1 person/15 m²	20	50
D3	Low-risk industrial	1 person/15 m²	15	37,5
D4	Plant rooms	N/A	5	5
E1	Places of detention	2 people/bedroom	15	37,5
E2	Hospitals	1 person/10 m²	10	87,6
E3	Other institutional residences	1 person/10 m²	10	25
E4	Health care	1 person/10 m²	10	87,6
F1	Large shops	1 person/10 m²	24	105,12
F2	Small shops	1 person/10 m²	20	87,6
F3	Wholesaler’s store	1 person/20 m²	15	65,7
G1	Offices	1 person/15 m²	17	42,5
H1	Hotels	2 people/bedroom	10	43,8
H2	Dormitories	1 person/5 m²	5	12,5
H3	Domestic residences	2 people/bedroom	5	5
H4	Dwelling houses	4 people/house	5	5
H5	Hospitality	2 people/bedroom	10	43,8
J1	High-risk storage	1 person/50 m²	17	42,5
J2	Moderate-risk storage	1 person/50 m²	15	37,5
J3	Low risk-storage	1 person/50 m²	7	17,5
J4	Parking areas covered	1 person/50 m²	5	21,9

Table 13 — Minimum *R*-value of pipe insulation

1	2
Internal diameter of pipe	**Minimum *R*-value**[a]
≤ 80 mm > 80 mm	1,00 1,50
[a] Determined with a hot surface temperature of 60 °C and an ambient temperature of 15 °C.	

4.5.2.6 Hot water vessels and tanks shall be insulated with a material achieving a minimum *R*-value of 2,0.

NOTE To achieve this value, insulation in addition to the manufacturers' installed insulation may be required.

4.5.2.7 Insulation on vessels, tanks and piping containing cooling water shall be protected by a vapour barrier on the outside of the insulation.

4.5.2.8 The piping insulation requirements do not apply to space heating water piping

a) located within the space being heated where the piping is to provide the heating to that space, or

b) encased within a concrete floor slab or in masonry.

These pipes shall comply with SANS 10252-1.

4.5.2.9 Piping to be insulated includes all flow and return piping, cold water supply piping within 1 m of the connection to the heating or cooling system and pressure relief piping within 1 m of the connection to the heating or cooling system. Where possible, lengths of pipe runs should be minimized.

4.6 Mechanical ventilation and air conditioning

4.6.1 General

4.6.1.1 Air conditioning or mechanical ventilation systems (or both) installed in buildings shall comply with the relevant national legislation (see foreword) and with provisions of 4.6.2 to 4.6.9 (inclusive). The air conditioning or mechanical ventilation system (or both) shall be designed to best practice and using the best available technology. The minimum component efficiencies and various system design parameters to achieve the best efficiency are given in 4.6.2 to 4.6.9, inclusive.

4.6.1.2 Buildings shall be so designed that in the event of failure of an air conditioning or mechanical ventilation system (or both), an alternative means of natural ventilation shall be provided.

4.6.2 Air side system design criteria — Distribution system

4.6.2.1 Separate distribution systems

If zones have special process temperature requirements or humidity requirements (or both), they shall be served by air distribution systems separate from those serving the zones requiring only comfort conditions, or shall be provided with supplementary control specifically for comfort purposes only, except where

a) the total supply air to the comfort heating or cooling zone(s) is no more than 25 % of the total system supply air primarily used in excess of special process purposes,

b) the total conditioned floor area of the zones requiring comfort heating or cooling is smaller than 100 m^2, and

c) the conditioned floor area is zoned based on the building orientation and avoids cooling and reheating to achieve the required indoor conditions.

4.6.2.2 Air leakage limit on ductwork

The leakage of the ductwork shall comply with SANS 10173.

4.6.3 Air side system design criteria — Fan system

4.6.3.1 General

4.6.3.1.1 The total fan motor power of a fan system shall satisfy the requirements of a constant air volume (CAV) fan system or a variable air volume (VAV) fan system, except where the system with total fan motor power is less than 5 kW. Due consideration shall be given to optimum efficiency when selecting the fan.

4.6.3.1.2 Additional fan motor power required by air treatment or filtering systems with clean pressure drop over 250 Pa need not be included. Additional fan motor power shall be calculated by using the following equation, and be deducted from the total fan motor power:

$$P_f = \frac{V(P_d - 250)}{N_m \times N_d \times N_f}$$

where

P_f is the fan motor power for air treatment or filtering, expressed in watts (W);

V is the air volume flow rate, expressed in cubic metres per second (m^3/s);

P_d is the clean air pressure drop of the filtering system, expressed in pascals (Pa);

N_m is the motor efficiency;

N_d is the drive or belt efficiency;

N_f is the fan efficiency.

4.6.3.2 Constant air volume (CAV) fan system

The total fan motor power required for a CAV fan system supplying constant air volume at design conditions shall not exceed 1,6 W/L/s of supply air quantity.

4.6.3.3 Variable air volume (VAV) fan system

The total fan motor power required for a VAV fan system shall be able to vary the system air volume automatically as a function of load at design conditions and shall not exceed 2,1 W/L/s of the supply air quantity. Any individual supply fan with a fan motor power of 5 kW or greater should incorporate controls and devices such that the fan motor demand is no more than 55 % of design wattage at 50 % of design air volume.

4.6.4 Water side system — Design criteria

4.6.4.1 Pumping system

Pumping systems shall be designed for variable flow if control valves of the system are designed to modulate or step open and closed as a function of load (i.e. two-way control valves). The system shall be capable of reducing system flow to 50 % of design flow or less, except in

a) systems where a minimum flow greater than 50 % of the design flow is required for the proper operation of equipment served by the system such as chillers,

b) systems that serve no more than one control valve, or

c) systems that include supply water temperature reset controls.

The pump shall have a minimum efficiency of 70 % at its design duty point.

4.6.4.2 Friction loss

The friction loss of a piping system shall not exceed an average of 350 Pa/m over the whole system. The designer should also consider lower friction loss for noise or erosion control.

4.6.5 Pipe and duct distribution system insulation

All chilled water, hot water and refrigeration piping, conditioned air duct work and flexible ducting shall be insulated to limit heat gain or loss (or both) to not more than 5 % from source to furthest point of delivery on a system.

4.6.6 Cooling and heating equipment

Cooling and heating equipment shall have efficiencies in accordance with ASHRAE 90.1.

4.6.7 Air-conditioning controls

4.6.7.1 Temperature control

4.6.7.1.1 Each air-conditioning system (AC) shall be provided with at least one automatic control device for regulation of temperature.

4.6.7.1.2 Thermostatic controls for comfort shall be capable of adjusting the set point temperature of the space they serve to between 20 °C and 24 °C.

NOTE It is recommended that the set points be 20 °C in winter and 24 °C in summer.

4.6.7.1.3 Thermostatic controls for both comfort cooling and heating shall be capable of providing a temperature range or dead band of at least 2,0 °C within which the supply of heating and cooling energy to the zone is shut off or reduced to a minimum.

4.6.7.2 Humidity control

If the air-conditioning system is equipped with a means for adding or removing moisture to maintain specific humidity levels in a zone or zones, a humidistat shall be provided. For comfort purposes, the humidistat shall be capable of preventing the use of energy to increase relative humidity above 30 % during humidification, or to decrease relative humidity below 60 % during dehumidification.

4.6.7.3 Zone control

4.6.7.3.1 Each air-conditioned zone shall be controlled by individual thermostatic control corresponding to temperature within the zone. Each floor of a building shall be considered as a separate zone, except where independent perimeter systems that are designed to offset only envelope heat losses or gains, or both, are used to serve one or more zones which are also served by an interior system with the following limitations:

a) the perimeter system includes at least one thermostatic control zone for each building exposure having exterior walls facing only one orientation for a touching distance of 15 m or more; and

b) the perimeter system heating and cooling supply are controlled by thermostat(s) located within the zone(s) served by the system.

4.6.7.3.2 Where both heating and cooling energy are provided to a zone, the controls shall be such as to prevent

a) heating previously cooled air,

b) cooling previously heated air,

c) both heating and cooling systems operating at the same time.

4.6.7.3.3 Where both heating and cooling energy are provided to a zone, the controls shall be such as to allow for:

a) VAV systems which, during periods of occupancy are designed to reduce the air supply to each zone to a minimum before re-heating re-cooling or mixing takes place;

   NOTE This minimum volume should be no greater than 30 % of the peak supply volume.

b) at least 75 % of the energy for re-heating or for providing warm air in mixing systems is provided from a site-recovered or site-solar energy source;

c) zones with a peak supply air quantity of 140 L/s, or less;

d) zones where specified humidity levels are required to satisfy process needs; and

e) re-heating or re-cooling of outdoor air which has been previously pre-cooled or pre-heated by pre-treating air handling units (PAUs).

4.6.8 Air and water economizers

Air and water economizers systems shall be considered for installations in climatic conditions where this will reduce energy consumption.

4.6.9 Unitary and packaged equipment

The minimum coefficients of performance of unitary and packaged air-conditioning equipment are given in table 14.

Where packaged units utilize ducted air-distribution systems, 4.6.2 shall apply.

Table 14 — Minimum coefficient of performance (COP) of unitary and packaged air-conditioning equipment

1	2	3
Equipment type	**Capacity range**[a] kW	**Minimum COP**[b,c]
Unitary (console) and split type	< 7	2,5
Packaged and split air conditioning	7 < 19	2,6
	10 < 40	2,96
	40 < 70	2,72
	> 70	2,64
Water cooled package	< 20	3,2

[a] If resistance heating is used, heating power consumption shall not exceed cooling power consumption except in the case of equipment of <10 kW.

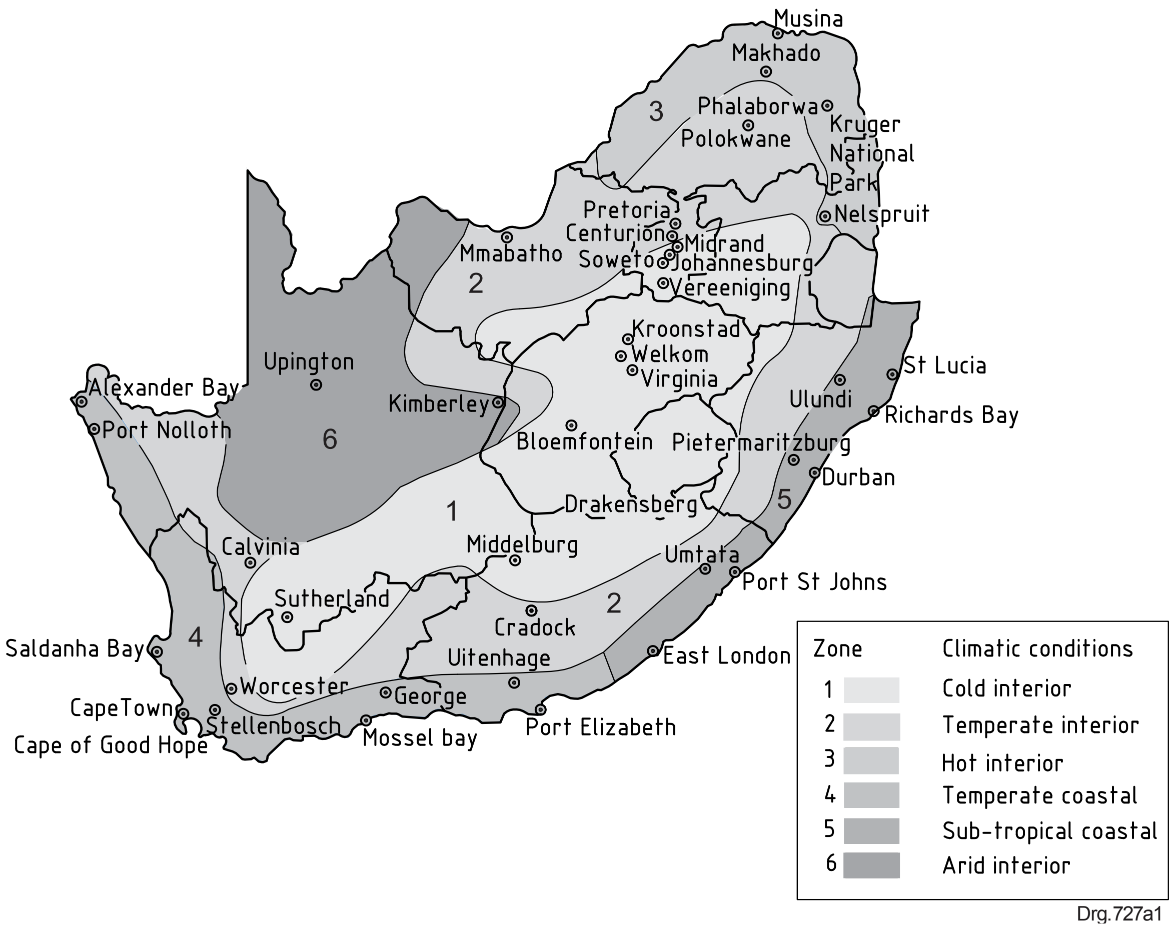
[b] COP shall be as determined under summer design condensing conditions of 35 °C dry bulb ambient for air-cooled systems and summer design wet bulb for water-cooled systems.

[c] COP shall include airside fan power but exclude waterside cooling system power.

Annex A
(normative)

Climatic zones of South Africa

The climatic zones of South Africa are shown in figure A.1, and the locations in such zones are given in table A.1.



Zone	Description	Major centre
1	Cold interior	Johannesburg, Bloemfontein
2	Temperate interior	Pretoria, Polokwane
3	Hot interior	Makhado, Nelspruit
4	Temperate coastal	Cape Town, Port Elizabeth
5	Sub-tropical coastal	East London, Durban, Richards Bay
6	Arid interior	Upington, Kimberley

Figure A.1 — Climatic zone map

Table A.1 — Locations of cities and towns according to climatic zone

1	2	1	2	1	2
Location	**Zone**	**Location**	**Zone**	**Location**	**Zone**
Alexander Bay	4	Jacobsdal	6	Pretoria	2
Aliwal North	1	Jan Kempdorp	1	Prieska	6
Amsterdam	2	Johannesburg	1	Pudimoe	1
Baberton	2	Kammieskroon	4	Queenstown	2
Badplaas	2	Kainoplaagte	6	Reivilo	2
Barrydale	4	Kimberley	6	Richards Bay	5
Beaufort West	2	Kingwilliamstown	5	Richmond	2
Bloemfontein	1	Kirkwood	4	Riversdale	4
Boshoff	2	Klerksdorp	1	Rooibokkraal	3
Brakpan	1	Kokstad	2	Sabie	3
Brandfort	2	Komatipoort	3	Sakrivier	6
Butterworth	5	Kroonstad	1	Saldanha Bay	4
Calvinia	2	Kruger National Park	3	Sibasa	3
Cape Agulhas	4	Krugersdorp	1	Soweto	1
Cape of Good Hope	4	Kubus	4	Springs	1
Cape Town	4	Kuruman	2	St Lucia	5
Cederberg	4	Ladysmith	2	Standerton	1
Centurion	2	Laingsburg	1	Stellenbosch	4
Ceres	2	Makhado	3	Steytlerville	2
Colesburg	1	Marken	3	Stoffberg	2
Conway	1	Melmoth	5	Stutterheim	2
Cradock	2	Mica	3	Swartberg	1
Dealsville	1	Middelburg	1	Swellendam	4
Delmas	1	Midrand	1	Thabazimbi	3
Dendron	2	Mkuze	5	Toska	6
Derdepoort	2	Mmabatho	2	Touwsrivier	2
Dordrecht	1	Mosselbay	4	Uitenhage	4
Drakensberg	1	Musina	3	Ulundi	5
Dullstroom	1	Nelspruit	3	Umtata	5
Dundee	2	Newcastle	1	Upington	6
Durban	5	Niewoudtville	4	Utrecht	2
East London	5	Northam	2	Ventersdorp	2
Elliot	1	Olifantshoek	6	Vereeninging	1
Ermelo	1	Ottosdal	2	Victoria West	1
Estcourt	2	Oudshoorn	2	Vioolsdrif	2
George	4	Petrusburg	1	Virginia	1
Gouda	4	Phalaborwa	3	Volksrust	1
Grahamstown	4	Piet Plessis	2	Vryburg	2
Graskop	3	Piet Retief	2	Warrinton	2
Gravelot	2	Pietermaritzburg	5	Watervalboven	1
Giyani	2	Pilgrims Rest	2	Welkom	1
Harrismith	1	Pofadder	6	Wellington	4
Hartbeesfontein	1	Polokwane	2	Williston	1
Heidelberg	4	Pongola	2	Witbank	1
Hopetown	1	Port Elizabeth	4	Worcester	2
Hotazel	2	Port Nolloth	4	Zeerust	2
Hutchinson	1	Port St Johns	5		

Annex B
(normative)

Building orientation

In figures B.1 to B.6 the effect of orientation of energy consumption for six cities is shown with the humidity control included in heating and the optimal true north orientation.

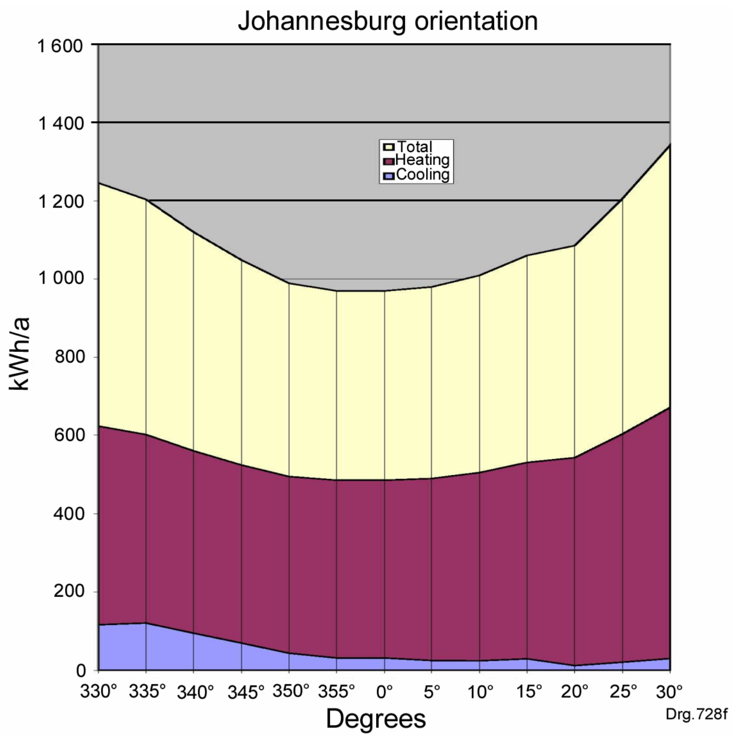


Figure B.1 — Johannesburg — Optimal orientation true north ± 15°

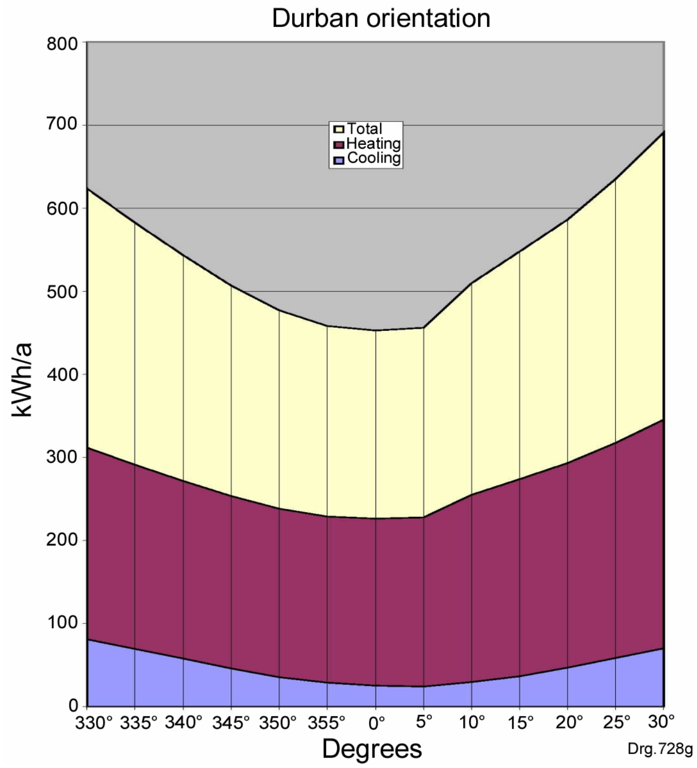


Figure B.2 — Durban — Optimal orientation true north +5° E and 12° W

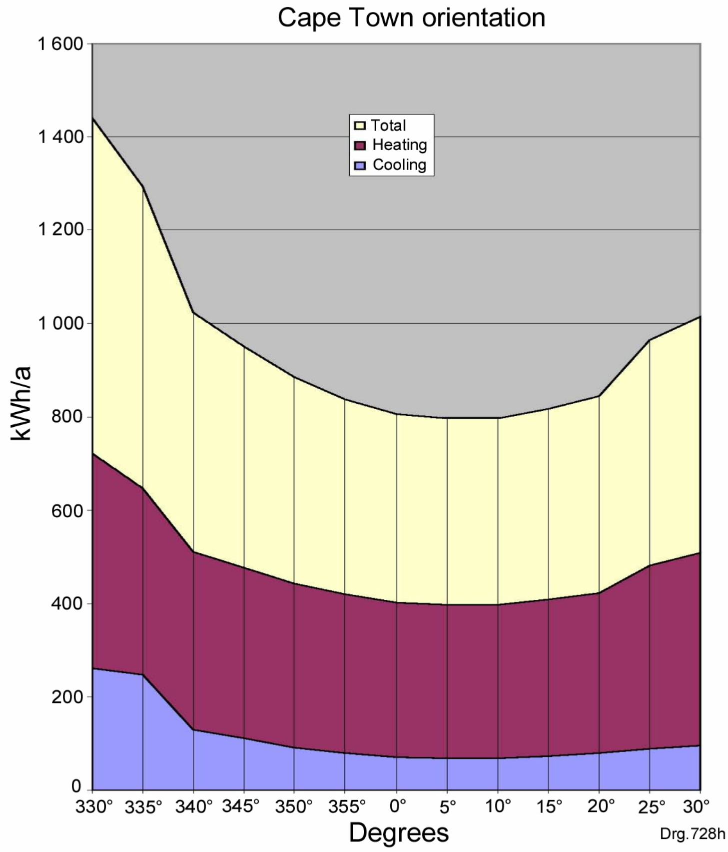


Figure B.3 — Cape Town — Optimal orientation true north +20° E and 8° W

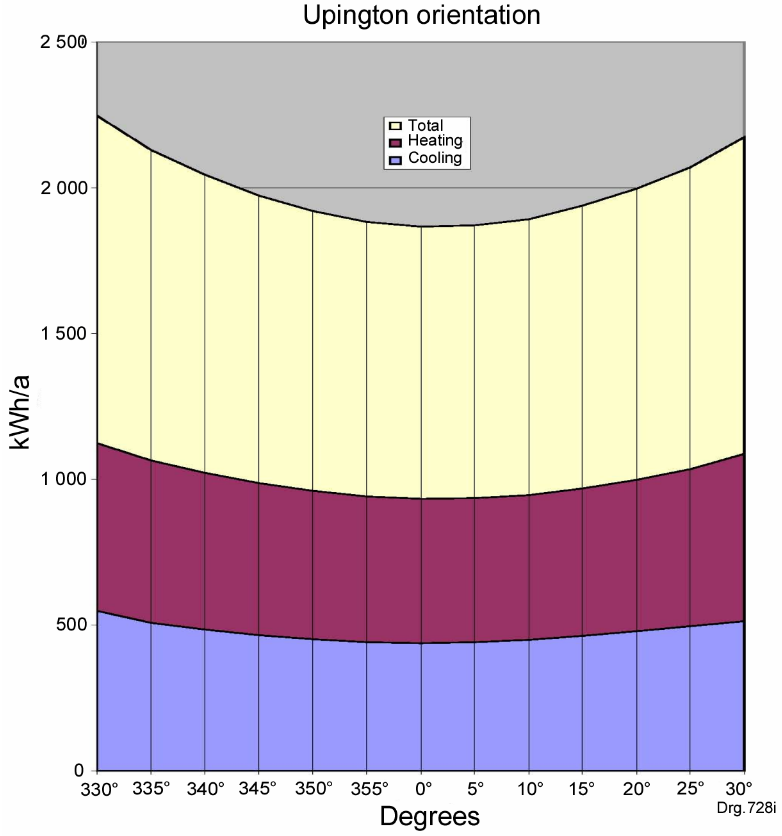


Figure B.4 — Upington — Optimal orientation true north ± 15°

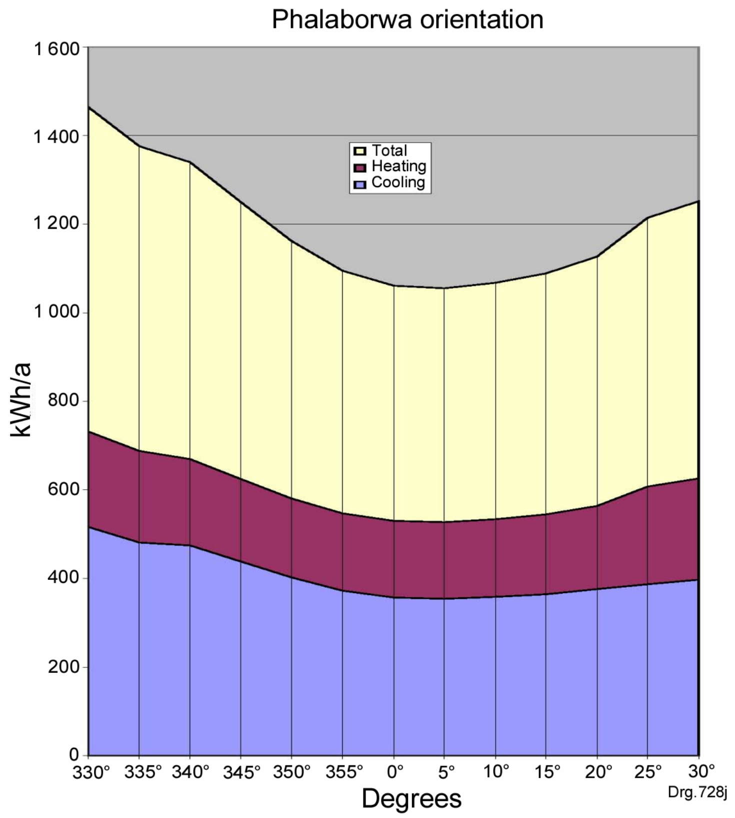


Figure B.5 — Phalaborwa — Optimal orientation true north +15° E and +5° W

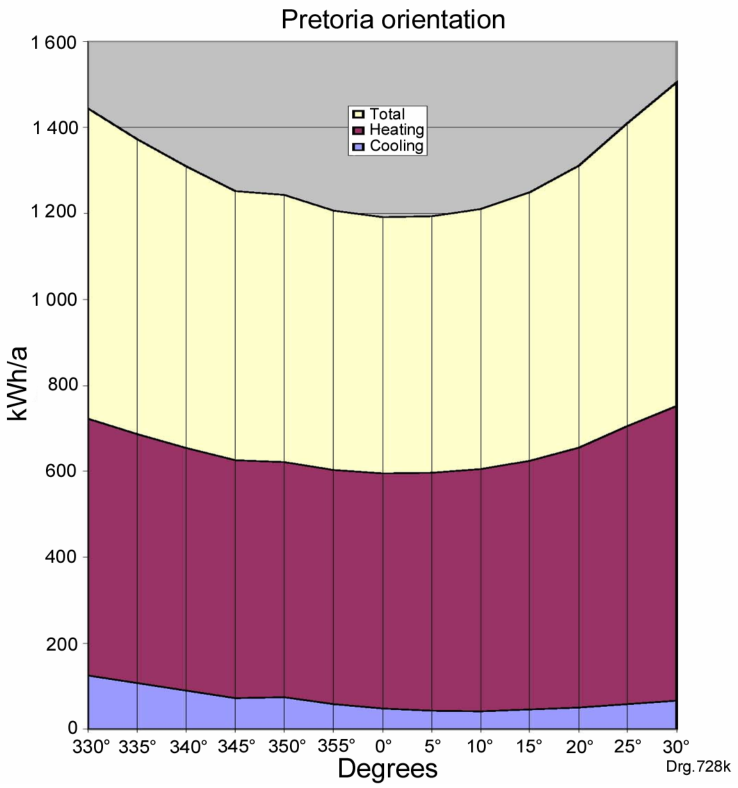


Figure B.6 — Pretoria — Optimal orientation true north +15° E and +10° W

Annex C
(normative)

Fenestration for buildings with natural environmental control — Solar exposure factor for each glazing element

The solar exposure factors for climatic zones 1 to 6 are given in tables C.1 to C.6.

Table C.1 — Solar exposure factors — Climatic zone 1

1	2	3	4	5	6	7	8	9
P/H (see figure 3)	**Solar exposure factors** *E* (m^{-2})							
	Orientation sector							
	North	**North East**	**East**	**South East**	**South**	**South West**	**West**	**North West**
0,00	0,84	1,08	1,15	0,87	0,61	1,05	1,40	1,24
0,05	0,71	0,97	1,05	0,78	0,52	0,96	1,30	1,13
0,10	0,65	0,90	0,99	0,74	0,49	0,91	1,25	1,04
0,15	0,58	0,83	0,93	0,69	0,47	0,86	1,18	0,97
0,20	0,52	0,77	0,88	0,65	0,44	0,82	1,12	0,91
0,25	0,48	0,72	0,84	0,62	0,42	0,78	1,06	0,85
0,30	0,44	0,68	0,80	0,59	0,40	0,75	1,01	0,80
0,35	0,40	0,63	0,75	0,57	0,38	0,71	0,95	0,75
0,40	0,36	0,58	0,71	0,54	0,36	0,67	0,90	0,69
0,50	0,33	0,51	0,66	0,49	0,33	0,63	0,83	0,60
0,60	0,30	0,43	0,61	0,45	0,31	0,58	0,76	0,51
0,70	0,28	0,39	0,56	0,42	0,29	0,54	0,71	0,45
0,80	0,26	0,35	0,50	0,38	0,26	0,50	0,66	0,40
0,90	0,24	0,32	0,46	0,35	0,25	0,46	0,61	0,38
1,00	0,22	0,29	0,42	0,32	0,23	0,42	0,56	0,36
1,10	0,21	0,26	0,40	0,30	0,23	0,41	0,52	0,32
1,20	0,20	0,24	0,37	0,29	0,23	0,39	0,48	0,29
1,30	0,19	0,23	0,34	0,27	0,21	0,36	0,45	0,27
1,40	0,18	0,22	0,32	0,26	0,19	0,34	0,42	0,26
1,50	0,17	0,21	0,30	0,25	0,19	0,32	0,40	0,24
1,60	0,16	0,19	0,28	0,24	0,18	0,31	0,38	0,21
1,70	0,16	0,19	0,27	0,23	0,18	0,29	0,36	0,20
1,80	0,15	0,18	0,26	0,22	0,17	0,28	0,34	0,20
1,90	0,15	0,18	0,25	0,21	0,17	0,27	0,32	0,19
2,00	0,14	0,17	0,24	0,21	0,17	0,26	0,31	0,17

Table C.2 — Solar exposure factors — Climatic zone 2

1	2	3	4	5	6	7	8	9
P/H (see figure 3)	**Solar exposure factors** *E* (m^{-2})							
	Orientation sector							
	North	**North East**	**East**	**South East**	**South**	**South West**	**West**	**North West**
0,00	0,82	1,09	1,19	0,96	0,68	1,04	1,30	1,16
0,05	0,69	0,96	1,07	0,85	0,57	0,92	1,19	1,04
0,10	0,63	0,88	1,01	0,79	0,54	0,86	1,11	0,94
0,15	0,57	0,82	0,95	0,75	0,51	0,81	1,05	0,88
0,20	0,51	0,76	0,89	0,70	0,48	0,76	0,99	0,83
0,25	0,48	0,72	0,85	0,67	0,46	0,72	0,95	0,77
0,30	0,45	0,67	0,80	0,64	0,43	0,69	0,90	0,72
0,35	0,42	0,63	0,76	0,60	0,41	0,65	0,85	0,67
0,40	0,39	0,58	0,71	0,57	0,38	0,62	0,81	0,62
0,50	0,37	0,52	0,65	0,52	0,36	0,56	0,73	0,55
0,60	0,35	0,46	0,58	0,47	0,33	0,51	0,65	0,48
0,70	0,32	0,42	0,54	0,43	0,31	0,47	0,59	0,44
0,80	0,30	0,37	0,50	0,40	0,28	0,43	0,52	0,40
0,90	0,28	0,34	0,46	0,37	0,26	0,40	0,49	0,35
1,00	0,26	0,31	0,42	0,34	0,25	0,37	0,46	0,31
1,10	0,25	0,28	0,39	0,32	0,23	0,35	0,43	0,29
1,20	0,24	0,26	0,36	0,30	0,22	0,33	0,40	0,27
1,30	0,23	0,25	0,34	0,28	0,21	0,31	0,37	0,26
1,40	0,21	0,23	0,32	0,27	0,20	0,29	0,34	0,24
1,50	0,21	0,22	0,30	0,25	0,19	0,28	0,32	0,23
1,60	0,20	0,22	0,29	0,23	0,18	0,27	0,30	0,21
1,70	0,19	0,21	0,27	0,22	0,18	0,25	0,29	0,20
1,80	0,18	0,20	0,25	0,21	0,17	0,23	0,27	0,20
1,90	0,18	0,19	0,24	0,21	0,17	0,22	0,26	0,19
2,00	0,17	0,17	0,24	0,21	0,16	0,21	0,25	0,19

Table C.3 — Solar exposure factors — Climatic zone 3

1	2	3	4	5	6	7	8	9
P/H (see figure 3)	**Solar exposure factors** *E* (m^{-2})							
	Orientation sector							
	North	**North East**	**East**	**South East**	**South**	**South West**	**West**	**North West**
0,00	0,56	1,04	1,42	1,18	0,66	1,16	1,36	1,01
0,05	0,47	0,94	1,32	1,08	0,57	1,05	1,26	0,90
0,10	0,44	0,85	1,25	1,02	0,54	0,99	1,19	0,83
0,15	0,41	0,79	1,17	0,96	0,50	0,93	1,13	0,78
0,20	0,38	0,73	1,10	0,90	0,46	0,87	1,06	0,73
0,25	0,36	0,69	1,05	0,85	0,44	0,83	1,00	0,68
0,30	0,35	0,64	0,99	0,81	0,42	0,79	0,95	0,64
0,35	0,34	0,60	0,93	0,76	0,40	0,75	0,90	0,60
0,40	0,32	0,56	0,88	0,71	0,38	0,72	0,84	0,56
0,50	0,30	0,49	0,81	0,65	0,35	0,64	0,77	0,50
0,60	0,28	0,43	0,74	0,58	0,31	0,57	0,71	0,44
0,70	0,26	0,39	0,67	0,53	0,29	0,53	0,65	0,40
0,80	0,24	0,35	0,59	0,47	0,27	0,50	0,60	0,35
0,90	0,22	0,32	0,54	0,44	0,25	0,46	0,56	0,32
1,00	0,20	0,29	0,50	0,40	0,24	0,43	0,53	0,29
1,10	0,20	0,28	0,46	0,37	0,22	0,40	0,48	0,28
1,20	0,19	0,26	0,42	0,34	0,21	0,37	0,43	0,26
1,30	0,18	0,24	0,39	0,33	0,20	0,35	0,42	0,25
1,40	0,17	0,22	0,35	0,31	0,20	0,32	0,41	0,23
1,50	0,17	0,21	0,34	0,29	0,18	0,32	0,38	0,22
1,60	0,17	0,20	0,33	0,27	0,16	0,31	0,35	0,21
1,70	0,16	0,19	0,31	0,25	0,16	0,29	0,34	0,20
1,80	0,15	0,19	0,30	0,24	0,16	0,28	0,33	0,19
1,90	0,15	0,18	0,28	0,24	0,15	0,26	0,30	0,18
2,00	0,15	0,18	0,25	0,24	0,15	0,24	0,27	0,17

Table C.4 — Solar exposure factors — Climatic zone 4

1	2	3	4	5	6	7	8	9
P/H (see figure 3)	**Solar exposure factors** E (m^{-2})							
	Orientation sector							
	North	**North East**	**East**	**South East**	**South**	**South West**	**West**	**North West**
0,00	0,84	1,08	1,15	0,87	0,61	1,05	1,40	1,24
0,05	0,71	0,97	1,05	0,78	0,52	0,96	1,30	1,13
0,10	0,65	0,90	0,99	0,74	0,49	0,91	1,25	1,04
0,15	0,58	0,83	0,93	0,69	0,47	0,86	1,18	0,97
0,20	0,52	0,77	0,88	0,65	0,44	0,82	1,12	0,91
0,25	0,48	0,72	0,84	0,62	0,42	0,78	1,06	0,85
0,30	0,44	0,68	0,80	0,59	0,40	0,75	1,01	0,80
0,35	0,40	0,63	0,75	0,57	0,38	0,71	0,95	0,75
0,40	0,36	0,58	0,71	0,54	0,36	0,67	0,90	0,69
0,50	0,33	0,51	0,66	0,49	0,33	0,63	0,83	0,60
0,60	0,30	0,43	0,61	0,45	0,31	0,58	0,76	0,51
0,70	0,28	0,39	0,56	0,42	0,29	0,54	0,71	0,45
0,80	0,26	0,35	0,50	0,38	0,26	0,50	0,66	0,40
0,90	0,24	0,32	0,46	0,35	0,25	0,46	0,61	0,38
1,00	0,22	0,29	0,42	0,32	0,23	0,42	0,56	0,36
1,10	0,21	0,26	0,40	0,30	0,23	0,41	0,52	0,32
1,20	0,20	0,24	0,37	0,29	0,23	0,39	0,48	0,29
1,30	0,19	0,23	0,34	0,27	0,21	0,36	0,45	0,27
1,40	0,18	0,22	0,32	0,26	0,19	0,34	0,42	0,26
1,50	0,17	0,21	0,30	0,25	0,19	0,32	0,40	0,24
1,60	0,16	0,19	0,28	0,24	0,18	0,31	0,38	0,21
1,70	0,16	0,19	0,27	0,23	0,18	0,29	0,36	0,20
1,80	0,15	0,18	0,26	0,22	0,17	0,28	0,34	0,20
1,90	0,15	0,18	0,25	0,21	0,17	0,27	0,32	0,19
2,00	0,14	0,17	0,24	0,21	0,17	0,26	0,31	0,17

Table C.5 — Solar exposure factors — Climatic zone 5

1	2	3	4	5	6	7	8	9
P/H (see figure 3)	**Solar exposure factors** *E* (m^{-2})							
	Orientation sector							
	North	**North East**	**East**	**South East**	**South**	**South West**	**West**	**North West**
0,00	0,52	0,84	1,29	1,24	0,87	1,27	1,32	0,85
0,05	0,44	0,74	1,19	1,13	0,75	1,17	1,23	0,75
0,10	0,41	0,68	1,11	1,07	0,68	1,09	1,15	0,69
0,15	0,39	0,64	1,06	1,00	0,61	1,02	1,08	0,64
0,20	0,37	0,59	1,01	0,94	0,55	0,94	1,00	0,60
0,25	0,35	0,56	0,95	0,88	0,52	0,89	0,96	0,57
0,30	0,33	0,52	0,90	0,82	0,48	0,85	0,92	0,53
0,35	0,32	0,49	0,84	0,76	0,45	0,80	0,88	0,50
0,40	0,30	0,45	0,79	0,69	0,42	0,75	0,83	0,47
0,50	0,27	0,41	0,72	0,64	0,38	0,67	0,75	0,42
0,60	0,25	0,37	0,66	0,59	0,34	0,60	0,66	0,38
0,70	0,24	0,34	0,59	0,53	0,32	0,56	0,62	0,35
0,80	0,22	0,31	0,53	0,47	0,30	0,52	0,58	0,32
0,90	0,20	0,28	0,49	0,44	0,27	0,48	0,53	0,30
1,00	0,19	0,26	0,45	0,41	0,25	0,43	0,48	0,28
1,10	0,18	0,24	0,41	0,37	0,23	0,41	0,45	0,27
1,20	0,18	0,23	0,37	0,33	0,22	0,39	0,42	0,26
1,30	0,17	0,22	0,35	0,32	0,22	0,36	0,40	0,24
1,40	0,17	0,21	0,32	0,30	0,22	0,32	0,37	0,22
1,50	0,16	0,20	0,30	0,28	0,20	0,31	0,36	0,22
1,60	0,15	0,18	0,28	0,26	0,18	0,29	0,34	0,21
1,70	0,14	0,18	0,28	0,24	0,18	0,29	0,32	0,20
1,80	0,13	0,18	0,27	0,22	0,17	0,28	0,30	0,18
1,90	0,13	0,18	0,25	0,22	0,17	0,26	0,29	0,17
2,00	0,12	0,17	0,23	0,21	0,16	0,24	0,28	0,17

Table C.6 — Solar exposure factors — Climatic zone 6

1	2	3	4	5	6	7	8	9
P/H (see figure 3)	**Solar exposure factors** E (m^{-2})							
	Orientation sector							
	North	**North East**	**East**	**South East**	**South**	**South West**	**West**	**North West**
0,00	0,72	1,19	1,40	1,05	0,57	0,99	1,31	1,12
0,05	0,61	1,10	1,31	0,97	0,49	0,91	1,22	1,02
0,10	0,56	1,00	1,24	0,91	0,46	0,85	1,17	0,94
0,15	0,49	0,94	1,18	0,86	0,44	0,81	1,11	0,87
0,20	0,43	0,87	1,12	0,82	0,41	0,76	1,05	0,81
0,25	0,40	0,82	1,07	0,78	0,39	0,73	1,00	0,76
0,30	0,37	0,76	1,02	0,74	0,38	0,69	0,95	0,71
0,35	0,33	0,71	0,97	0,71	0,36	0,66	0,90	0,66
0,40	0,30	0,66	0,92	0,67	0,34	0,62	0,85	0,62
0,50	0,29	0,58	0,83	0,61	0,31	0,58	0,79	0,53
0,60	0,27	0,50	0,74	0,56	0,29	0,53	0,72	0,45
0,70	0,26	0,44	0,68	0,52	0,27	0,49	0,66	0,40
0,80	0,24	0,38	0,63	0,49	0,25	0,45	0,59	0,36
0,90	0,22	0,35	0,59	0,46	0,23	0,42	0,55	0,33
1,00	0,20	0,31	0,55	0,42	0,22	0,39	0,51	0,30
1,10	0,20	0,29	0,50	0,39	0,21	0,37	0,48	0,27
1,20	0,19	0,26	0,46	0,37	0,20	0,35	0,45	0,25
1,30	0,17	0,24	0,43	0,35	0,18	0,34	0,41	0,23
1,40	0,16	0,23	0,39	0,34	0,17	0,33	0,38	0,21
1,50	0,16	0,21	0,38	0,32	0,17	0,31	0,35	0,21
1,60	0,16	0,20	0,38	0,30	0,16	0,29	0,33	0,20
1,70	0,15	0,19	0,35	0,29	0,15	0,27	0,32	0,18
1,80	0,14	0,18	0,32	0,27	0,14	0,25	0,32	0,17
1,90	0,14	0,17	0,30	0,25	0,14	0,24	0,29	0,16
2,00	0,13	0,17	0,28	0,23	0,14	0,24	0,26	0,16

Annex D
(normative)

Fenestration for buildings with artificial ventilation or air conditioning

Energy constants are given in table D.1, the heating shading multiplier is given in table D.2 and the cooling shading multiplier is given in table D.3.

Table D.1 — Energy constants

1	2	3	4	5	6	7	8	9	10
Climatic zone	**Energy constants**	**Orientation section**							
		North	**North East**	**East**	**South East**	**South**	**South West**	**West**	**North West**
1	C_A	−0,37	−0,38	−0,59	−0,82	−0,87	−0,90	−0,85	−0,61
	C_B	1,53	1,66	1,39	0,80	0,38	0,66	1,07	1,34
	C_C	−0,01	−0,01	0,03	0,11	0,15	0,13	0,08	0,03
2	C_A	−0,06	−0,09	−0,18	−0,41	−0,47	−0,43	−0,28	−0,14
	C_B	1,46	1,55	1,32	0,75	0,41	0,68	1,13	1,38
	C_C	−0,02	−0,01	0,00	0,05	0,07	0,05	0,02	−0,01
3	C_A	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
	C_B	1,01	1,16	1,08	0,69	0,41	0,67	1,01	1,09
	C_C	0,01	0,01	0,01	0,02	0,01	0,01	0,01	0,01
4	C_A	−0,37	−0,38	−0,59	−0,82	−0,87	−0,90	−0,85	−0,61
	C_B	1,53	1,66	1,39	0,80	0,38	0,66	1,07	1,34
	C_C	−0,01	−0,01	0,03	0,11	0,15	0,13	0,08	0,03
5	C_A	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
	C_B	0,80	0,92	0,91	0,67	0,48	0,67	0,88	0,91
	C_C	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02
6	C_A	−0,16	−0,18	−0,30	−0,44	−0,45	−0,46	−0,40	−0,26
	C_B	1,25	1,37	1,18	0,68	0,35	0,60	0,98	1,20
	C_C	0,00	0,00	0,03	0,07	0,09	0,08	0,04	0,02

Table D.2 — Heating shading multiplier

1	2	3	4	5	6	7	8	9	10	11
Climatic zones	***G*** (see figure 3) mm	***P/H*** (see figure 3)	**Heating shading multiplier** S_H							
			Orientation section							
			North	**North East**	**East**	**South East**	**South**	**South West**	**West**	**North West**
1 and 4	≤ 100	0,00	1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,0
		0,2	0,95	0,93	0,91	0,90	0,93	0,91	0,91	0,93
		0,4	0,82	0,82	0,78	0,79	0,86	0,81	0,78	0,80
		0,6	0,61	0,66	0,64	0,70	0,80	0,71	0,64	0,62
		0,8	0,31	0,46	0,49	0,63	0,74	0,63	0,52	0,41
		1,0	0,02	0,23	0,35	0,58	0,70	0,56	0,40	0,17
		1,2	0,00	0,04	0,23	0,53	0,66	0,51	0,30	0,02
		1,4	0,00	0,00	0,14	0,49	0,63	0,47	0,22	0,00
		1,6	0,00	0,00	0,10	0,45	0,60	0,44	0,16	0,00
		1,8	0,00	0,00	0,05	0,41	0,58	0,41	0,11	0,00
		2,0	0,00	0,00	0,01	0,37	0,55	0,38	0,05	0,00
	> 100 but < 500	0,00	1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,0
		0,2	0,99	0,99	0,98	0,97	0,97	0,97	0,97	0,98
		0,4	0,96	0,94	0,91	0,89	0,93	0,91	0,91	0,94
		0,6	0,88	0,87	0,83	0,82	0,87	0,84	0,82	0,86
		0,8	0,75	0,78	0,73	0,70	0,83	0,76	0,71	0,75
		1,0	0,57	0,66	0,62	0,68	0,78	0,69	0,61	0,60
		1,2	0,33	0,51	0,51	0,64	0,75	0,63	0,52	0,44
		1,4	0,14	0,37	0,42	0,60	0,72	0,59	0,44	0,30
		1,6	0,10	0,25	0,33	0,57	0,69	0,55	0,36	0,20
		1,8	0,05	0,12	0,25	0,53	0,67	0,51	0,29	0,10
		2,0	0,00	0,00	0,17	0,50	0,64	0,48	0,21	0,00
	> 500 but < 1 200	0,00	1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,0
		0,2	1,00	0,99	0,99	0,99	0,99	0,99	0,99	0,99
		0,4	0,99	0,98	0,97	0,96	0,97	0,96	0,96	0,98
		0,6	0,97	0,96	0,93	0,92	0,94	0,92	0,92	0,96
		0,8	0,94	0,93	0,89	0,87	0,91	0,88	0,87	0,92
		1,0	0,88	0,88	0,83	0,82	0,87	0,83	0,81	0,86
		1,2	0,79	0,82	0,77	0,77	0,85	0,79	0,75	0,79
		1,4	0,66	0,73	0,69	0,73	0,82	0,75	0,68	0,69
		1,6	0,48	0,63	0,62	0,69	0,79	0,70	0,61	0,57
		1,8	0,30	0,53	0,54	0,66	0,76	0,66	0,55	0,45
		2,0	0,13	0,42	0,47	0,63	0,74	0,62	0,48	0,33

Table D.2 (*concluded*)

1	2	3	4	5	6	7	8	9	10	11
Climatic zones	***G*** (see figure 3) mm	***P/H*** (see figure 3)	**Heating shading multiplier** S_H							
			Orientation section							
			North	**North East**	**East**	**South East**	**South**	**South West**	**West**	**North West**
3 and 5	All	All	1,0							
2 and 6	≤ 100	0,00	1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,0
		0,2	0,96	0,95	0,92	0,90	0,94	0,92	0,92	0,95
		0,4	0,86	0,83	0,79	0,78	0,87	0,83	0,80	0,85
		0,6	0,66	0,65	0,63	0,69	0,81	0,74	0,66	0,70
		0,8	0,30	0,41	0,43	0,62	0,77	0,66	0,50	0,47
		1,0	0,00	0,08	0,22	0,56	0,74	0,60	0,35	0,15
		1,2	0,00	0,00	0,08	0,52	0,71	0,54	0,21	0,00
		1,4	0,00	0,00	0,04	0,48	0,69	0,50	0,12	0,00
		1,6	0,00	0,00	0,02	0,45	0,67	0,46	0,08	0,00
		1,8	0,00	0,00	0,01	0,42	0,66	0,43	0,04	0,00
		2,0	0,00	0,00	0,00	0,39	0,64	0,39	0,00	0,00
	> 100 but < 500	0,00	1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,0
		0,2	0,99	0,99	0,98	0,97	0,98	0,97	0,98	0,99
		0,4	0,97	0,95	0,92	0,89	0,93	0,91	0,92	0,96
		0,6	0,91	0,88	0,84	0,81	0,88	0,85	0,85	0,90
		0,8	0,79	0,78	0,73	0,70	0,84	0,79	0,75	0,81
		1,0	0,59	0,63	0,62	0,67	0,80	0,73	0,65	0,69
		1,2	0,27	0,45	0,48	0,63	0,78	0,68	0,54	0,50
		1,4	0,03	0,28	0,35	0,59	0,75	0,63	0,44	0,31
		1,6	0,02	0,19	0,25	0,56	0,74	0,59	0,34	0,21
		1,8	0,01	0,09	0,14	0,52	0,72	0,55	0,25	0,10
		2,0	0,00	0,00	0,03	0,49	0,70	0,51	0,15	0,00
	> 500 but < 1 200	0,00	1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,0
		0,2	1,00	1,00	0,99	0,99	0,99	0,99	0,99	0,99
		0,4	0,99	0,98	0,97	0,97	0,97	0,96	0,97	0,99
		0,6	0,98	0,97	0,94	0,92	0,95	0,93	0,94	0,97
		0,8	0,95	0,94	0,90	0,88	0,92	0,89	0,90	0,94
		1,0	0,91	0,89	0,84	0,83	0,89	0,85	0,84	0,90
		1,2	0,82	0,82	0,78	0,78	0,86	0,82	0,78	0,84
		1,4	0,67	0,71	0,70	0,73	0,84	0,78	0,71	0,75
		1,6	0,45	0,58	0,60	0,70	0,81	0,74	0,64	0,62
		1,8	0,22	0,44	0,51	0,66	0,79	0,71	0,56	0,48
		2,0	0,00	0,30	0,42	0,62	0,77	0,67	0,49	0,35

NOTE In climate zones 1, 2, 4 and 6, where *G* is more than 1 200 mm, the heating shading multiplier is taken as 1,0.

Table D.3— Cooling shading multiplier

1	2	3	4	5	6	7	8	9	10	11
Climatic zones	***G*** (see figure 3) mm	***P/H*** (see figure 3)	**Cooling shading multiplier** S_C							
			Orientation section							
			North	**North East**	**East**	**South East**	**South**	**South West**	**West**	**North West**
1 and 4	≤ 100	0,00	1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,0
		0,2	0,82	0,86	0,87	0,87	0,90	0,88	0,87	0,84
		0,4	0,63	0,69	0,72	0,74	0,80	0,74	0,72	0,67
		0,6	0,49	0,56	0,60	0,64	0,73	0,64	0,61	0,54
		0,8	0,40	0,46	0,51	0,56	0,68	0,57	0,52	0,44
		1,0	0,35	0,38	0,44	0,51	0,64	0,51	0,45	0,38
		1,2	0,32	0,34	0,39	0,48	0,61	0,47	0,41	0,35
		1,4	0,31	0,32	0,36	0,45	0,59	0,44	0,37	0,32
		1,6	0,30	0,30	0,33	0,42	0,57	0,42	0,34	0,31
		1,8	0,30	0,29	0,31	0,41	0,56	0,40	0,32	0,30
		2,0	0,30	0,28	0,29	0,39	0,55	0,38	0,31	0,29
	>100 but < 500	0,00	1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,0
		0,2	0,93	0,95	0,95	0,95	0,95	0,95	0,95	0,95
		0,4	0,79	0,84	0,86	0,86	0,88	0,86	0,85	0,82
		0,6	0,64	0,71	0,75	0,76	0,81	0,76	0,74	0,68
		0,8	0,52	0,60	0,65	0,63	0,75	0,68	0,65	0,57
		1,0	0,43	0,51	0,57	0,61	0,71	0,61	0,57	0,48
		1,2	0,38	0,44	0,50	0,56	0,68	0,56	0,50	0,42
		1,4	0,35	0,39	0,45	0,52	0,65	0,52	0,46	0,38
		1,6	0,33	0,35	0,41	0,49	0,63	0,49	0,42	0,35
		1,8	0,32	0,33	0,38	0,47	0,62	0,46	0,39	0,33
		2,0	0,31	0,31	0,36	0,45	0,60	0,44	0,36	0,32
	> 500 but < 1 200	0,00	1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,0
		0,2	0,97	0,98	0,98	0,98	0,98	0,98	0,98	0,98
		0,4	0,91	0,94	0,94	0,94	0,94	0,94	0,94	0,93
		0,6	0,82	0,87	0,88	0,88	0,90	0,88	0,87	0,85
		0,8	0,72	0,79	0,81	0,82	0,85	0,81	0,80	0,75
		1,0	0,62	0,70	0,74	0,76	0,81	0,75	0,73	0,66
		1,2	0,53	0,62	0,67	0,70	0,77	0,70	0,67	0,58
		1,4	0,47	0,55	0,62	0,65	0,74	0,65	0,61	0,51
		1,6	0,42	0,49	0,56	0,61	0,72	0,61	0,56	0,46
		1,8	0,38	0,44	0,51	0,57	0,69	0,57	0,51	0,42
		2,0	0,35	0,40	0,47	0,54	0,67	0,54	0,47	0,38

Table D.3 (*continued*)

1	2	3	4	5	6	7	8	9	10	11
Climatic zones	***G*** (see figure 3) mm	***P/H*** (see figure 3)	**Cooling shading multiplier** S_C							
			Orientation section							
			North	**North East**	**East**	**South East**	**South**	**South West**	**West**	**North West**
2 and 6	≤ 100	0,00	1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,0
		0,2	0,81	0,85	0,87	0,86	0,90	0,88	0,87	0,84
		0,4	0,61	0,68	0,72	0,72	0,81	0,75	0,72	0,67
		0,6	0,46	0,54	0,59	0,61	0,74	0,64	0,60	0,53
		0,8	0,35	0,42	0,49	0,53	0,68	0,57	0,51	0,42
		1,0	0,28	0,34	0,42	0,47	0,64	0,50	0,44	0,34
		1,2	0,24	0,29	0,37	0,43	0,62	0,46	0,38	0,29
		1,4	0,22	0,26	0,33	0,39	0,59	0,42	0,34	0,26
		1,6	0,20	0,23	0,30	0,36	0,57	0,39	0,31	0,24
		1,8	0,20	0,21	0,27	0,34	0,56	0,37	0,29	0,22
		2,0	0,19	0,20	0,25	0,32	0,54	0,34	0,26	0,21
	>100 but < 500	0,00	1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,0
		0,2	0,93	0,95	0,96	0,95	0,96	0,95	0,95	0,95
		0,4	0,77	0,83	0,86	0,85	0,89	0,86	0,85	0,82
		0,6	0,62	0,70	0,74	0,74	0,82	0,77	0,74	0,68
		0,8	0,48	0,58	0,64	0,60	0,76	0,68	0,64	0,56
		1,0	0,37	0,48	0,55	0,58	0,72	0,61	0,56	0,46
		1,2	0,32	0,40	0,48	0,52	0,68	0,56	0,50	0,39
		1,4	0,28	0,35	0,43	0,48	0,66	0,52	0,44	0,34
		1,6	0,25	0,30	0,39	0,45	0,64	0,48	0,40	0,30
		1,8	0,23	0,27	0,35	0,42	0,62	0,45	0,37	0,27
		2,0	0,21	0,25	0,32	0,39	0,60	0,42	0,34	0,25
	> 500 but <1 200	0,00	1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,0
		0,2	0,97	0,98	0,98	0,98	0,98	0,98	0,98	0,98
		0,4	0,90	0,94	0,94	0,94	0,95	0,94	0,94	0,93
		0,6	0,81	0,86	0,88	0,87	0,91	0,88	0,88	0,85
		0,8	0,70	0,77	0,81	0,81	0,87	0,81	0,80	0,75
		1,0	0,58	0,68	0,74	0,74	0,82	0,76	0,73	0,66
		1,2	0,47	0,60	0,67	0,68	0,79	0,70	0,66	0,58
		1,4	0,40	0,52	0,61	0,62	0,75	0,65	0,60	0,50
		1,6	0,35	0,46	0,55	0,58	0,73	0,61	0,55	0,44
		1,8	0,31	0,41	0,50	0,54	0,70	0,57	0,50	0,39
		2,0	0,27	0,36	0,45	0,50	0,68	0,54	0,46	0,35

Table D.3 (*concluded*)

1	2	3	4	5	6	7	8	9	10	11
Climatic zones	***G*** (see figure 3) mm	***P/H*** (see figure 3)	**Cooling shading multiplier** S_C							
			Orientation section							
			North	**North East**	**East**	**South East**	**South**	**South West**	**West**	**North West**
3 and 5	≤ 100	0,00	1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,0
		0,2	0,79	0,84	0,86	0,85	0,87	0,87	0,87	0,84
		0,4	0,57	0,66	0,71	0,70	0,76	0,73	0,72	0,67
		0,6	0,41	0,52	0,58	0,58	0,68	0,62	0,60	0,53
		0,8	0,32	0,40	0,47	0,48	0,62	0,54	0,50	0,43
		1,0	0,26	0,32	0,39	0,42	0,58	0,48	0,43	0,35
		1,2	0,22	0,28	0,33	0,38	0,56	0,43	0,37	0,30
		1,4	0,20	0,24	0,29	0,34	0,53	0,39	0,33	0,25
		1,6	0,19	0,22	0,26	0,32	0,52	0,36	0,29	0,22
		1,8	0,18	0,20	0,23	0,30	0,50	0,33	0,26	0,20
		2,0	0,17	0,18	0,21	0,28	0,49	0,31	0,24	0,18
	>100 but < 500	0,00	1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,0
		0,2	0,92	0,94	0,95	0,94	0,93	0,94	0,95	0,94
		0,4	0,72	0,81	0,85	0,83	0,84	0,84	0,85	0,81
		0,6	0,54	0,68	0,73	0,72	0,77	0,75	0,74	0,68
		0,8	0,42	0,56	0,63	0,57	0,71	0,66	0,64	0,56
		1,0	0,34	0,46	0,54	0,54	0,66	0,59	0,56	0,47
		1,2	0,29	0,38	0,46	0,48	0,62	0,54	0,49	0,41
		1,4	0,25	0,32	0,40	0,43	0,60	0,50	0,44	0,35
		1,6	0,23	0,29	0,35	0,40	0,57	0,46	0,39	0,31
		1,8	0,21	0,26	0,32	0,37	0,56	0,42	0,36	0,38
		2,0	0,20	0,24	0,29	0,34	0,54	0,39	0,32	0,25
	> 500 but <1 2 00	0,00	1,0	1,0	1,0	1,0	10	1,0	1,0	10
		0,2	0,97	0,98	0,98	0,98	0,96	0,98	0,98	0,98
		0,4	0,89	0,93	0,94	0,93	0,91	0,93	0,94	0,92
		0,6	0,74	0,85	0,88	0,6	0,86	0,86	0,87	0,84
		0,8	0,59	0,76	0,81	0,79	0,81	0,80	0,80	0,74
		1,0	0,49	0,66	0,73	0,72	0,77	0,73	0,72	0,66
		1,2	0,41	0,58	0,66	0,65	0,73	0,68	0,66	0,58
		1,4	0,35	0,51	0,59	0,59	0,69	0,63	0,60	0,51
		1,6	0,31	0,44	0,53	0,54	0,66	0,59	0,55	0,46
		1,8	0,28	0,39	0,48	0,50	0,64	0,55	0,50	0,41
		2,0	0,25	0,35	0,43	0,46	0,61	0,51	0,45	0,37
NOTE In climate zones 1, 2, 4 and 6, where *G* is more than 1 200 mm, the cooling shading multiplier is taken as 1,0.										

Annex E
(normative)

Requirements for the glazing assessment

E.1 General

E.1.1 Fenestration refers to the arrangement, proportioning, and design of windows and doors in a building. The energy efficiency of the building envelope is greatly impacted by the fenestration systems. Windows strongly influence the use of the building and the productivity and comfort of its occupants.

E.1.2 The factors to be considered when evaluating thermal performance of fenestration shall be as follows:

a) the *U*-factor, sometimes referred to as *U*-value or thermal transmittance;

b) the solar heat gain coefficient (*SHGC*) and visible transmittance (VT);

c) the solar optical properties;

d) the air leakage rating; and

e) the condensation resistance rating.

E.1.3 With glazing, this standard requires that total *U*-values and *SHGC*s shall be assessed for the combined effect of the glass and frame. The measurement of these total *U*-values and *SHGC*s are specified in the guidelines of the National Fenestration Rating Council (NFRC).

The method used in this standard is based on the system performance of glazing being assessed in accordance with NFRC 100 conditions.

E.2 Glazing performance and evidence of suitability

E.2.1 Total *U*-values and *SHGC*s, based on the NFRC assessment methods for some simple types of residential glazing elements are given in table E.1. (Lower numbers indicate better glazing element performance.) Table E.1 gives worst-case assessments of residential glazing elements, which can be improved by obtaining generic or custom product assessments from suppliers, manufacturers, industry associations (including their online resources) and from competent assessors.

Custom assessments consider glazing element components in more detail and return the highest levels of assessed performance for a given type of glazing element.

Generic assessments consider the components of glazing elements in less detail and return lower levels of assessed performance.

Table E.1 — Worst-case whole residential glazing element performance values

1	2	3	4	5
Glass description	**Performance values**			
	Aluminium or steel framing		**Timber or uPVC framing**	
	Total *U*-value	***SHGC***	**Total *U*-value**	***SHGC***
Single clear	7,9	0,81	5,6	0,77
Single tinted	7,9	0,65	5,6	0,61
Double clear (3/6/3)	6,2	0,72	3,8	0,68

E.2.2 Typical ranges of generic ratings are given in table E.2 to illustrate the levels of performance available through such assessments. Values given in table E.2 should not be used in compliance calculations.

The approach is to relate glazing performance to glazing area and its degree of exposure to solar radiation. This enables unlimited mixing of glazing sizes, glass and frame types, and shading projections or other external shading devices. No internal shading devices are considered in this standard.

E.2.3 The means by which heat enters or leaves a room through glazing are conduction, solar radiation and infiltration (air leaks). Air infiltration is covered under sealing requirements (see 4.4.2). Conduction through glazing occurs when there is a temperature difference between the inside and the outside of the glazing. Conduction through both glass and frames shall be considered as a unit.

Solar radiation passes through glazing as direct beams of sunlight but also as diffuse (or scattered) radiation and as reflected radiation. The intensity of solar radiation from different directions varies throughout the year and is also affected by the amount of shading provided to the glazing.

E.2.4 Glazing requirements in each climatic zone are specified by separate constants for conductance and for solar radiation (or solar heat gain). These constants are labelled C_U and C_{SHGC} in table 5, and set the performance targets for each storey of a naturally ventilated building. The constants for conductance and solar radiation are each multiplied by the floor area of the naturally ventilated building to determine the performance targets that apply to that particular space in a given climatic zone.

In a south facing window conductance will often be the critical factor while in west and east facing windows, solar radiation will usually be the critical factor.

Table E.2 — Indicative ranges of whole residential glazing element performance values

1	2	3	4	5	6	7
Glass description		**Comment**	**Performance values**			
			Total *U*-value range		***SHGC* range**	
			Aluminium framing	**Timber or uPVC framing**	**Aluminium framing**	**Timber or uPVC framing**
Single (monolithic or laminated)	Clear	Minimal variation in glass *U*-value and *SHGC* for different glass thicknesses.	7,9 to 5,5	5,6 to 4,3	0,81 to 0,64	0,77 to 0,51
	Tinted	Glass *SHGC* depends on glass thickness and type of tint.	7,9 to 5,6	5,6 to 4,3	0,65 to 0,33	0,61 to 0,25
	Coated	Glass *U*-value and *SHGC* depend on coating type.	7,8 to 3,8	5,5 to 2,9	0,68 to 0,36	0,64 to 0,27
	Tinted and coated	Glass *U*-value depends on coating type. Glass *SHGC* depends on coating type, type of tint and glass thickness.	7,8 to 3,8	5,5 to 3,1	0,45 to 0,31	0,42 to 0,23
Double	Clear	Glass *U*-value depends on cavity width.	6,2 to 3,1	3,8 to 2,5	0,72 to 0,63	0,68 to 0,47
	Tinted	Glass *U*-value depends on cavity width. Glass *SHGC* depends on type of tint, tinted glass thickness and on cavity width.	6,2 to 3,1	3,8 to 2,5	0,57 to 0,36	0,57 to 0,27
	Coated	Glass *U*-value depends on cavity width and type of coating. Glass *SHGC* depends on type of coating and cavity width.	6,1 to 2,4	3,8 to 2,1	0,60 to 0,22	0,59 to 0,17
	Tinted and coated	Glass *U*-value depends on cavity width and type of coating. Glass *SHGC* depends on type of coating, tinted glass thickness and cavity width.	6,1 to 2,5	3,8 to 2,1	0,41 to 0,21	0,37 to 0,16

E.2.5 This standard provides the method for calculating the combined performance of all the glazing on each storey of a naturally ventilated building.

The following equations set the solar and conductance performance of each glazing element in the proposed installation:

a) For conductance:

$A \times U$

where

A is the glazing area;

U is the U-value of the glazing.

The total U-value includes the effect of coatings and cavities between panes. Acceptable values for use in the equation can be obtained from the manufacturer's published data, and shall be in the NFRC 100 format.

It is imperative that the user is clear that a total U-value obtained from a manufacturer or supplier is for the glazing system (glass and frame combined). Some manufacturers may publish a single "winter" value while others may publish values for both "winter" and "summer". For consistency, the glazing requirement has been formulated to allow the "winter" value to be used in all areas of South Africa (including those without a significant winter). Glass manufacturers do not refer to total U-value but rather just U-value. In the total U-value calculation, it does not matter which orientation the glazing faces.

b) For solar radiation:

$A \times SHGC \times E$

where

A is the glazing area facing a particular orientation;

$SHGC$ is the solar heat gain coefficient of the glass and frame;

E is the solar exposure factor.

The *SHGC* of the glazing can be obtained from the manufacturer's data. It is imperative that the user is clear that a *SHGC* value obtained from a manufacturer or supplier is for the glazing system (glass and frame). The solar exposure factors are provided in tables C.1 to C.6. The factors make allowance for the different amounts of solar radiation received from different directions and for the extent of physical shading that is proposed. The required solar radiation performance shall be achieved by the glazing itself if it is un-shaded, or if shaded, by a combination of glazing and shading.

E.2.6 In measuring the shading projection, note that for walls, the shading projection is measured from the wall face, whereas for glazing, the projection is measured from the glass face. Also, the provisions are based on any projection that is to provide shading that is extended on both sides of the glazing for a distance equal to the required projection distance. This is because there is significant flanking of any shading that is only the width of the glazing when the sun is at an acute angle to the wall. An alternative would be vertical shading.

E.3 Orientation sectors

E.3.1 General

Figure 1 shows how the direction that the glazing faces is determined. It is the direction that a perpendicular line from the glazing itself faces. The figure is based on true north and all angles are measured clockwise from true north.

Survey angles on site plans are usually marked in angles from true north. These angles can be used to establish true north for a particular site. Magnetic north, found by a magnetic compass, varies from true north over time and by different amounts in different locations. Magnetic north is not an acceptable approximation of true north.

The eight orientation sectors shown in figure 1 do not overlap at their boundaries. North sector, for example, begins just clockwise after the NNW line and ends exactly on the NNE line. The start and end of other sectors are determined in a similar way, as indicated by the outer curved arrows.

E.3.2 Example of the orientation of a sole occupancy unit

E.3.2.1 The unit

A small sole-occupancy unit with a total floor area of 60 m^2 in climatic zone 2 should be glazed with insulated single pane glass.

There is a similar unit situated directly above providing shading over the balcony (see figure E.1). It has two external walls facing northeast and southeast, a ceiling height of 2,7 m, a 3 m wide balcony outside the studio on the northeast wall and four panels of external glazing (including the doors opening to the balcony).

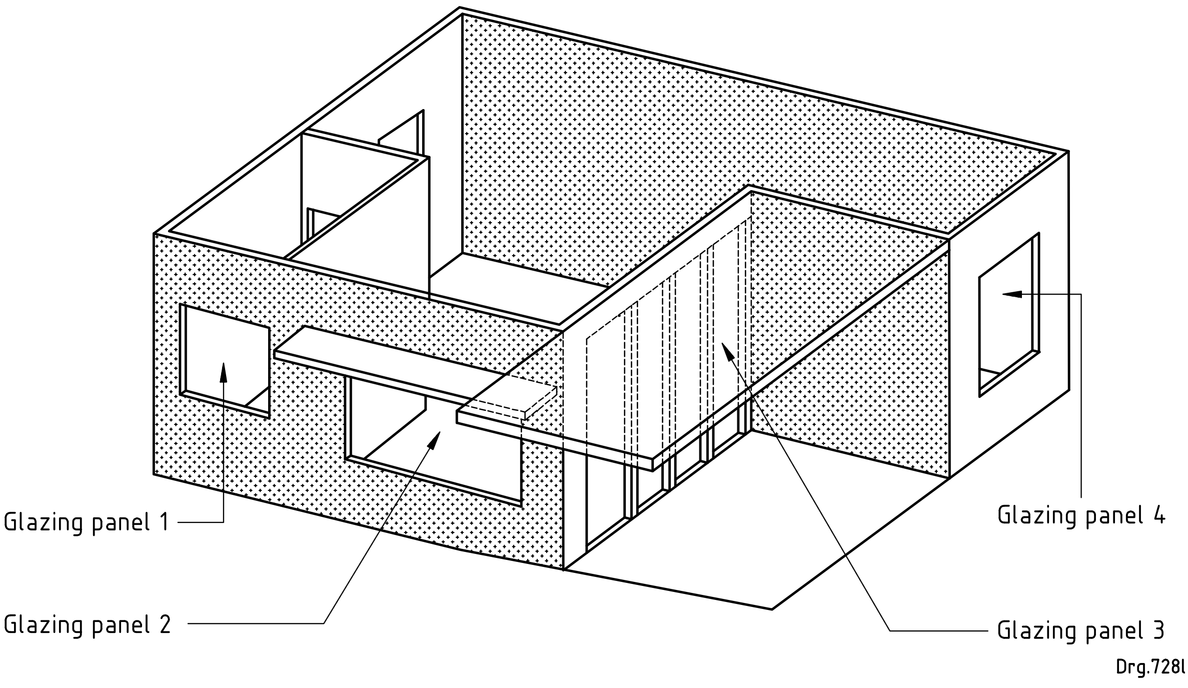


Figure E.1 — Sole occupancy unit

E.3.2.2 Glazing panel details

The glazing panel details are given in table E.3.

Table E.3 — Panels versus shading descriptions

1	2	3	4
Panel	**Facing direction**	**Area** m^2	**Shading description**
1	SE	1,4	Un-shaded
2	SE	3,6	Shaded by a 500 mm projection at window head
3	NE	11,3	Shaded by a 3 m balcony above
4	NE	2,2	Un-shaded
Total glazing area		18,5	
NOTE 1 All glazing is proposed as single pane glass in thermally aluminium frames. NOTE 2 Taking the worst-case assessment of the four glazing panels (see table E.1), the *U*-value of the glazing (glass and frame) is 7,9 and the *SHGC* of the glazing (clear glass and frame) is 0,81.			

E.3.2.3 Calculations for conductance

E.3.2.3.1 Use the following calculation for each glazing panel:

$$(A_1 \times U_1) + (A_2 \times U_2) + (A_3 \times U_3) + (A_4 \times U_4) < A_T \times C_u$$

where

$A_{1,\,2,\,3,\,4}$ are the floor areas, expressed in square metres (m^2);

$U_{1,\,2,\,3\,4}$ are the *U*-values, expressed in watts per square metre kelvin ($W/m^2{\cdot}K$);

A_T is the total floor area, expressed in square metres (m^2);

C_u is the conductance constant for climatic zone 2 as given in table 5.

EXAMPLE

Using the values in tables E.2 and E.3

$$(1,4 \times 7,9) + (3,6 \times 7,9) + (11,3 \times 7,9) + (2,2 \times 7,9) = 146,15\ W/K$$

and the total floor area multiplied by the conductance constant is

$$A_T \times C_u = 60 \times 1,4$$

$$= 84\ W/K$$

therefore the sum of the calculations > $A_T \times C_u$.

The proposed design does therefore does not comply for conductance.

E.3.2.3.2 In order to ensure compliance the system *U*-value shall be improved by using insulated glazing or a thermally improved frame in one or all of the installations. Note that the method does not limit the designer to using only one type of glazing in the building. The ratio of glazed area to floor area is relatively high at 30,8 %, against the minimum of 10 % required by SANS 10400-N; compliance may therefore be met by reducing the ratio of window area to floor area.

The total glazing area (18,5 m^2) could simply be multiplied by the *U*-value (7,9), because the *U*-value calculation does not consider which way the glazing faces and the same glass and frame types are used in all panels.

E.3.2.4 Calculations for solar heat gain

E.3.2.4.1 To find the appropriate solar exposure factors, *E*, in climatic zone 2, first calculate the *P/H* values (see figure 3 and table E.4).

Table E.4 — *P/H* values versus solar exposure factors

1	2	3
Panel	***P/H*** **value** (see figure 3)	**Solar exposure factor** (see table C.2)
1	0/1200 = 0	0,96 for SE
2	500/1500 = 0,33	0,64 for SE
3	3000/2700 = 1,11	0,28 for NE
4	0/1200 = 0	1,09 for NE
NOTE For greater precision interpolation can be applied.		

E.3.2.4.2 Use the following calculation for each glazing panel:

$$(A_1 \times S_1 \times E_1) + (A_2 \times S_2 \times E_2) + (A_3 \times S_3 \times E_3) + (A_4 \times S_4 \times E_4) < A_T \times C_{SHGC}$$

where

$A_{1,2,3,4}$ are the areas, expressed in square metres (m^2);

$SHGC_{1,2,3,4}$ are the solar heat gain coefficients;

$E_{1,2,3,4}$ are the solar exposure factors;

A_T is the total floor area, expressed in square metres (m^2);

C_{SHGC} is the solar heat gain constant, given in table 5 for climatic zone 2.

EXAMPLE

Using the values in tables E.3 and E.4

(1,4 × 0,810 × 0,96) + (3,6 × 0,810 × 0,64) + (11,3 × 0,810 × 0,28) + (2,2 × 0,810 × 1,09)

= 7,4601

and

$A_T \times C_{SHGC}$ = 60 × 0,12 = 7.20

therefore the sum of the calculations > $A_T \times C_{SHGC}$.

The proposed design does therefore does not comply for solar heat gain.

E.3.2.5 Conclusion

The proposed glazing installation is therefore not compliant with the conductance requirement or with the solar heat gain requirement.

Annex F
(informative)

General explanatory information on roof and ceiling construction

F.1 Ventilation

F.1.1 The roof space ventilation option applies to a pitched roof with a flat ceiling to ensure that efficient cross ventilation is achieved in the roof space to remove hot air. Roof space ventilation is generally not acceptable for most flat, skillion, cathedral ceiling and similar roof types because of the lack of space between the ceiling and the roof.

F.1.2 Care should be taken to ensure that the roof ventilation openings do not allow rain penetration.

F.1.3 Gaps between roof tiles with sarking (or reflective insulation at rafter level) and metal sheet roofing are not acceptable methods of providing roof space ventilation.

F.1.4 Compliance with ventilation provisions may result in the ingress of wind driven rain or fine dust, or stimulate the growth of mould or fungus in the roof enclosure. Consideration should therefore be given to the surrounding environmental features.

F.2 Coloured roofs

A light-coloured roof reduces the flow of heat from solar radiation more effectively than a dark-coloured roof. The solar absorptance value of a light-coloured roof (white, off-white, cream or dull zinc aluminium) is less than 0,55.

Typical absorptance values are as given in table F.1 (see BCA 2007).

Table F.1 — Typical absorptance values

1	2
Colour	**Value**
Slate (dark grey)	0,90
Red, green	0,75
Yellow, buff	0,60
Zinc aluminium (dull)	0,55
Galvanised steel (dull)	0,55
Light grey	0,45
Off white	0,35
Light cream	0,30

F.3 Heat flow direction

The direction of heat flow given in table 8 is considered to be the predominant direction of heat flow for the hours of occupation of the building. The higher rate of occupancy of houses is taken into account at night-time rather than during daytime.

F.4 Ventilated buildings

F.4.1 Naturally ventilated buildings

In hot humid climates where buildings are naturally ventilated, high down *R*-values and low up *R*-values are appropriate for roofs and ceilings.

F.4.2 Artificially ventilated buildings

Artificial cooling of buildings in some climates can cause condensation to form inside the layers of the building envelope. Such condensation can cause significant structural or cosmetic damage to the envelope before it is detected. Associated mould growth may also create health risks to the occupants. Effective control of condensation is a complex issue. In some locations a fully sealed vapour barrier may need to be installed on the more humid, or generally warmer, side of the insulation.

Typical *R*-values for air spaces, air films and roof and ceiling construction are given in tables F.2 and F.3.

Table F.2 — Typical *R*-values for air spaces and air films

1	2	3	4
Description	**Position of air space**	**Direction of heat flow**	***R*-value**
Air spaces non-reflective unventilated	Pitched roof space	Up	0,18
	Pitched roof space	Down	0,28
	Horizontal	Up	0,15
	Horizontal	Down	0,22
	45° slope	Up	0,15
	45° slope	Down	0,18
	Vertical	Horizontal	0,16
Air films – Still air	Pitched roof space	Up	Nil
	Pitched roof space	Down	0,46
	Horizontal	Up	0,11
	Horizontal	Down	0,16
	45° slope	Up	0,11
	45° slope	Down	0,13
	Vertical	Horizontal	0,12
Air films – Moving air	7 m/s wind	Any direction	0,03
	3 m/s wind	Any direction	0,04

Table F.3 — Typical *R*-values for roof and ceiling construction

1	2	3	4	5	6
Roof construction description	**Component**	***R*-value unventilated**		***R*-value ventilated**[a]	
		Up	**Down**	**Up**	**Down**
Roof 22° to 45° pitch with horizontal ceiling, and metal cladding	Outdoor air film (7 m/s)	0,03	0,03	0,03	0,03
	Metal cladding	0	0	0	0
	Roof air space (non-reflective)	0,18	0,28	0	0,46
	Plasterboard, gypsum (10 mm, 880 kg/m^3)	0,06	0,06	0,06	0,06
	Indoor air film (still air)	0,11	0,16	0,11	0,16
	Total *R*-value	0,38	0,53	0,20	0,71
Roof 22° to 45° pitch with horizontal ceiling, and clay tiles 19 mm	Outdoor air film (7 m/s)	0,03	0,03	0,03	0,03
	Roof tile, clay or concrete (1 922 kg/m^3)	0,02	0,02	0,02	0,02
	Roof air space (non-reflective)	0,18	0,28	0	0,46
	Plasterboard, gypsum (10 mm, 880 kg/m^3)	0,06	0,06	0,06	0,06
	Indoor air film (still air)	0,11	0,16	0,11	0,16
	Total *R*-value	0,40	0,55	0,22	0,73
Cathedral ceiling 22° to 45° pitch with 10 mm plasterboard on top of rafters, and metal external cladding	Outdoor air film (7 m/s)	0,03	0,03	–	–
	Metal cladding	0	0	–	–
	Roof air space (30 mm to 100 mm, non-reflective)	0,16	0,18	–	–
	Plasterboard, gypsum (10 mm, 880 kg/m^3)	0,06	0,06	–	–
	Indoor air film (still air)	0,11	0,16	–	–
	Total *R*-value	0,36	0,43	–	–
Cathedral ceiling 22° to 45° pitch with 10 mm plaster on top of rafters, and tiles with external cladding	Outdoor air film (7 m/s)	0,03	0,03	–	–
	Roof tile, clay or concrete (1 922 kg/m^3)	0,02	0,02	–	–
	Roof air space (30 mm to 100 mm, non-reflective)	0,10	0,18	–	–
	Plasterboard, gypsum (10 mm, 880 kg/m^3)	0,06	0,06	–	–
	Indoor air film (still air)	0,11	0,16	–	–
	Total *R*-value	0,32	0,45	–	–

Table F.3 (*concluded*)

1	2	3	4	5	6
Roof construction description	**Component**	***R*-value unventilated**		***R*-value ventilated**[a]	
		Up	**Down**	**Up**	**Down**
Skillion roof 2° to 12° pitch with 10 mm plaster below the rafters and external metal cladding	Outdoor air film (7 m/s)	0,03	0,03	–	–
	Metal cladding	0	0	–	–
	Roof air space (100 mm to 300 mm, non-reflective)	0,15	0,22	–	–
	Plasterboard, gypsum (10 mm, 880 kg/m^3)	0,06	0,06	–	–
	Indoor air film (still air)	0,11	0,16	–	–
	Total *R*-value	0,35	0,47	–	–
Skillion roof greater than 12° pitch with 10 mm plaster, suspended ceiling, and applied external waterproof membrane	Outdoor air film (7 m/s)	0,03	0,03	–	–
	Metal cladding	0	0	–	–
	Roof air space (30 mm to 100 mm non-reflective)	0,15	0,22	–	–
	Plasterboard, gypsum (10 mm, 880 kg/m^3)	0,07	0,07	–	–
	Indoor air film (still air)	0,11	0,16	–	–
	Total *R*-value	0,36	0,48	–	–
100 mm solid concrete roof with 10 mm plaster, suspended ceiling, and applied external waterproof membrane	Outdoor air film (7 m/s)	0,03	0,03	–	–
	Waterproof membrane, rubber synthetic (4 mm, 961 kg/m^3)	0,03	0,03	–	–
	Solid concrete, (100 mm, 2 400 kg/m^3)	0,07	0,07	–	–
	Ceiling air space (100 mm to 300 mm, non-reflective)	0,15	0,22	–	–
	Plasterboard, gypsum (10 mm, 880 kg/m^3)	0,06	0,06	–	–
	Indoor air film (still air)	0,11	0,16	–	–
	Total *R*-value	0,45	0,57	–	–

NOTE 1 The *R*-value of an item, other than an air space, air film or air cavity, may be increased in proportion to the increased thickness of the item.

NOTE 2 The total *R*-value of a form of construction may be increased by the amount that the *R*-value of an individual item is increased.

[a] For ventilated spaces, the ventilation rate should not be less than 0,5 L/s·m^2.

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